

MULTISTAGE HYBRID TREATMENT OF AORTIC ANEURYSM AND MANAGEMENT OF POSTOPERATIVE COMPLICATIONS: A CASE REPORT

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ABSTRACT

The Frozen Elephant Trunk (FET) is a surgical procedure developed for simultaneous repair of the aortic arch and the proximal descending thoracic aorta. Experience has shown its technical feasibility and good clinical results, although complications remain possible.

Case Presentation: A 66-year-old male presented for evaluation due to findings from computed tomography angiography of aneurysms in the ascending aorta, aortic arch, and abdominal aorta. The patient had a history of a quadruple coronary artery bypass graft (CABG) and placement of two stents in the descending thoracic aorta, which were improperly aligned, thrombosed, and further complicated the case. The patient underwent surgery involving sternotomy to perform the FET procedure, replacing the ascending aorta and aortic arch and placing a stent graft in the proximal descending thoracic aorta. Simultaneously, two coronary artery bypass grafts were performed. Postoperatively, the patient was stable, and the intervention outcome was satisfactory. Subsequently, endovascular treatment was carried out on the remaining thoracic aorta and abdominal blood vessels. However, respiratory failure necessitated the placement of stent grafts in the left main bronchus on two occasions. Despite extensive efforts, the patient succumbed to respiratory insufficiency.

Conclusion: Timely intervention and a multidisciplinary approach played a key role in addressing complications, although the patient ultimately experienced a fatal outcome due to multiorgan failure.

Keywords: aortic pathology; aortic dissection; arch aneurysm; frozen elephant trunk; hybrid treatment; respiratory insufficiency; bronchial stenting

INTRODUCTION

The aorta is the body's main artery, originating from the heart and supplying the entire body with oxygen-rich blood and nutrients. The most common pathological conditions associated with serious, life-threatening complications are aneurysms, dissections, and penetrating atherosclerotic ulcers [1]. An aortic aneurysm is an abnormal dilation of its wall, typically defined as an increase in diameter of over 50% of the normal size. These dilations most frequently occur in the ascending aorta (~60%) or the aortic arch (~10%),

though some patients may have simultaneous involvement of multiple locations. Aortic dissection, on the other hand, occurs when the intimal layer tears, allowing blood to enter the media, and thereby creating a false lumen with serious hemodynamic consequences. Penetrating ulcers and intramural hematomas further threaten aortic integrity, complicating disease progression [1]. Aortic aneurysms are anatomically categorized as thoracic aortic aneurysms (TAA), abdominal aortic aneurysms (AAA), and thoracoabdominal

aortic aneurysms (TAAA), which result from continuous dilation of the descending aorta extending into the abdominal aorta [2]. Treatment of these complex conditions, collectively termed "Aortic Syndrome," involves surgical replacement of the pathological aortic segment with a synthetic graft to restore normal blood flow. In cases where the aortic arch and descending aorta are affected, advanced hybrid procedure such as the "Frozen Elephant Trunk" provides a superior approach. By combining surgical and endovascular techniques, they stabilize the aorta and address remaining pathological changes. This technique enables repair of the aortic arch and thoracic aorta in a single step, involving a Dacron prosthesis connected to a self-expanding stent graft. This approach reduces the risks of staged surgeries required in traditional Elephant Trunk procedures and provides a stable platform for subsequent endovascular treatment of the descending aorta [3–6]. Historically, the Frozen Elephant Trunk (FET) procedure evolved through several key stages. In 1983, Borst et al. introduced the two-stage Elephant Trunk procedure for treating extensive thoracic aortic diseases, involving prosthetic replacement of the entire aortic arch with a continuation (trunk) left free in the descending aorta, necessitating a second operation. In 1996, Kato et al. first reported using a stent graft in the aorta to eliminate the need for a second surgery. In 2003, Kark presented the FET as a unified technique, combining aortic arch replacement with stent graft placement, simplifying subsequent endovascular treatment and eliminating the need for descending aorta replacement (6). Despite improving long-term outcomes, FET is not without risks. Neurological complications such as spinal cord or brain deficits occur in 10–20% of cases (reversible) and 15–21% (irreversible) [7–9]. Respiratory complications, including pneumonia and acute respiratory distress syndrome, occur in 20–40% of cases [10]. Cardiovascular issues, infections, and bleeding are also significant, particularly in patients with preexisting comorbidities or renal insufficiency.

Despite these challenges, FET remains a key therapeutic option for patients with complex aortic pathologies. This report reviews clinical outcomes and complications in a patient who underwent this procedure, focusing on factors contributing to specific complications and their management.

CASE PRESENTATION

We present the case of a 66-year-old male, an active smoker with dyslipidemia, who presented with symptoms of fatigue, shortness of breath, abdominal pain, and back pain. On admission, the patient's status showed no Marfanoid or other syndromic phenotype. The patient was obese, with a body mass index of 38.9 kg/m². His medical history included a quadruple coronary artery bypass graft (CABG) performed in another facility nine years prior, complicated by a postoperative acute myocardial infarction due to occlusion of the bypass graft to the right coronary artery. Three years before the current presentation, the patient underwent a thoracic endovascular aortic repair (TEVAR) procedure, also at another facility, involving the placement of two stent grafts in the descending thoracic aorta. However, due to malpositioning of the stent grafts, improper overlap at the proximal segment of the distal stent graft occurred, leading to discontinuity and the presence of a type 1 endoleak in the thrombosed wall of the aneurysm, measuring 17 mm in length. The patient was admitted to our facility with a plan for myocardial revascularization and thoracic aorta repair as the first stage, followed by repair of the distal thoracic aorta and abdominal aorta in the next stage. Respiratory function tests indicated mild pulmonary ventilatory insufficiency with a restrictive component. The Tiffeneau index was 100%, and the forced expiratory volume in the first second (FEV1) was 82%. Microbiological and laboratory analyses showed no deviations from the reference range. Echocardiography revealed an ejection fraction (EF) of 50%, with no significant segmental wall motion abnormalities, normal dimensions, and a functioning valvular apparatus, aside from mild mitral regurgitation. Doppler studies of the carotid arteries and peripheral vessels in the extremities were normal for the patient's age. Coronary angiography revealed occlusion of three out of four previously constructed coronary bypass grafts. Computed tomography angiography of the aorta confirmed the initial diagnosis, showing an ascending aorta diameter of 47 mm, an aortic arch diameter of 78

mm, a descending thoracic aorta diameter of 74 mm, and an abdominal aorta diameter of 44 mm.

The patient underwent surgery under general endotracheal anesthesia. Through a median sternotomy, access was provided for the complete replacement of the ascending aorta, the aortic arch, and the placement of a stent graft in the proximal descending thoracic aorta. Additionally, during the same operation, a double coronary artery bypass was performed using two venous grafts for the left anterior descending and right coronary arteries. The cannulation strategy included arterial cannulation via a graft to the right axillary artery and venous cannulation into the right atrium. Additional arterial lines were connected to the common carotid artery and the left

subclavian artery, ensuring conditions for maintaining trilateral antegrade cerebral perfusion. Immediately after the stent graft was placed, an arterial line was established to initiate systemic perfusion. Following the completion of total aortic replacement using the Frozen Elephant Trunk (FET) method (Figure 1), under mild hypothermia at 28 degrees Celsius, coronary artery bypass, and total aortic replacement, the patient was rewarmed and successfully weaned off cardiopulmonary bypass without complications, albeit with inotropic and vasopressor support. The total operation duration was 360 minutes.

The patient was transferred to the intensive care unit (ICU), where he remained intubated for less than 72 hours and stayed for 15 days

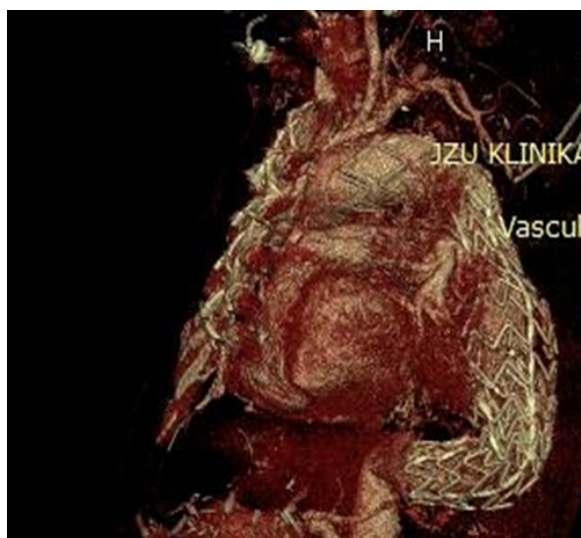


Figure 1. *Placed stent graft (FET) of the ascending aorta, arch and proximal segment of the descending aorta, and previous TEVAR stents of the thoracic aorta*

before being moved to the general ward. During his ICU stay, the patient developed acute kidney injury (AKI), for which a program of temporary hemodialysis was initiated. After stabilizing, the patient was discharged home. However, six days later, he was readmitted due to respiratory deterioration. Investigations revealed left lung atelectasis and an associated infection. Computed tomography (CT) of the lungs showed compression of the left bronchus by the stent graft. As a result, a stent was placed in the left main bronchus, which temporarily improved and stabilized the patient's condition. The patient was treated with aggressive antibiotic therapy based on culture sensitivity results. Ten days later, respiratory deterioration recurred due to displacement of the bronchial stent, which was subsequently re-

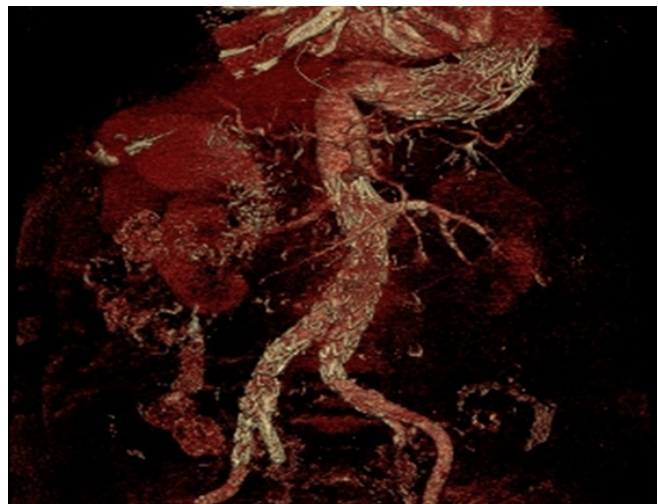
moved and replaced. The next stage of treatment, 45 days after stabilization, involved endovascular repair of the distal thoracic aorta and abdominal vessels. A stent was placed in the thoracic aorta, abdominal aorta, left common iliac artery, left internal iliac artery, and left renal artery (Figures 2 and 3). Post-endovascular treatment, the patient was hemodynamically stable and independent of mechanical ventilation.

A few days later, his condition deteriorated again, with impaired gas exchange and recurrence of acute kidney injury. The patient was placed on temporary hemodialysis without improvement. Over the following days, multi-organ failure (MOF) developed. Despite all resuscitative efforts, the patient succumbed to his condition.



Figure 2. proximally: FET stent graft of the thoracic aorta, stent-in-stent, new stent of the descending thoracic aorta, placed above the previous two. Distally, abdominal aorta with stent (EVAR) and stents of the iliac arteries and renal artery

Figure 3. FET on the ascending aorta, arch and descending thoracic aorta, TEVAR of the distal segment of the descending thoracic aorta, EVAR of the abdominal aorta, E-iliac stent-graft of the iliac arteries, E-ventus stent of the internal left iliac artery and E-V



DISCUSSION

This case represents an example of a multi-stage hybrid treatment for complex aortic pathology, including an ascending aneurysm, an aortic arch, and an abdominal aorta, further complicated by challenges from previously malpositioned stent grafts and occluded coronary bypass grafts. The achieved outcome highlights the capability of the Frozen Elephant Trunk (FET) procedure to provide stability and create the potential for subsequent endovascular treatment, while also emphasizing the severity of potential complications. The FET procedure allowed for the simultaneous surgical resolution of the aortic arch and proximal descending aorta. Through median

sternotomy and a complex cannulation strategy, antegrade cerebral perfusion was maintained, in accordance with the latest guidelines from EACTS/STS [1-3, 11]. The additional coronary artery bypass provided revascularization, which was critical for the patient's stability. However, the duration of the surgery (360 minutes) and the need for inotropic support increased the risk of complications. The requirement for inotropic and vasopressor support following the Frozen Elephant Trunk (FET) procedure is indicative of hemodynamic instability and significantly increases the risk of postoperative complications. Patients requiring prolonged use of these therapies have a higher incidence of multiorgan dysfunction, acute kidney injury (AKI), and increased mortality, particularly within the first 30 days postoperatively [2, 6, 12]. In our case, the

patient experienced several serious complications, including respiratory deterioration, acute kidney injury, and infection. Respiratory failure and atelectasis of the left lung required a dual interventional approach with the placement of a bronchial stent graft. This confirms the high incidence of respiratory complications in FET patients (20–40%) [2, 6, 10, 13]. Open surgeries are frequently followed by postoperative pulmonary complications such as pleural effusion, respiratory infection, respiratory failure, and atelectasis. Given the significant fluid shifts, pharmacological hemodynamic support, cardiopulmonary bypass (CPB), and sternotomy involved in aortic surgery, strategies to protect the lungs, such as optimized ventilation and perfusion, are crucial in reducing the risk of postoperative pulmonary complications [2, 13]. Additionally, in our case, the patient developed acute kidney injury (AKI), a known complication in patients undergoing open aortic surgery. This association was identified more than 60 years ago, with the cardiopulmonary bypass machine being recognized as a key factor contributing to the development of AKI. In general cardiovascular surgeries, the incidence of AKI is approximately 30%, with 5% requiring renal replacement therapy, either temporary or permanent. However, in more complex aortic surgeries, such as open thoracoabdominal aortic reconstruction or repair of acute type A aortic dissection, the need for renal replacement increases to 7–15% [2, 10, 14].

CONCLUSION

This case underscores the importance of the new recommendations from the EACTS/STS Guidelines, which advocate for early risk recognition and a proactive approach to minimizing complications. Research aimed at improving surgical techniques and postoperative care remains critical for enhancing outcomes in patients undergoing this highly invasive procedure. Timely intervention and a multidisciplinary approach play a key role in managing complications, although, due to multiorgan failure, a fatal outcome is not unexpected.

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Резиме

МУЛТИЕТАПЕН ХИБРИДЕН ТРЕТМАН НА АОРТНА АНЕВРИЗМА И РЕШАВАЊЕ НА ПОСТОПЕРАТИВНИ КОМПЛИКАЦИИ – ПРЕЗЕНТАЦИЈА НА СЛУЧАЈ

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Frozen Elephant Trunk (ФЕТ) е хируршка процедура што е развиена за истовремена поправка на аортниот лак и проксималната десцендентна торакална аорта. Искуството покажало техничка изводливост и добри клинички резултати, но сè уште се можни компликации.

Приказ на случајот: 66-годишен пациент се јавува на преглед поради наод од компјутерска ангиографија за аневризма на асцендентен дел и лак на аорта, како и абдоминална аорта. Инаку, претходно опериран четирикратен аорто-коронарен бајпас и поставени два стента на десцендентна торакална аорта, кои имаат несоодветно меѓусебно налегнување со тромбозирање и дополнително го отежнуваат случајот. Пациентот се подложи на операција со стернотомија за изведување на ФЕТ-процедура, со замена на асцендентен дел и лак на аорта и антеградно пласирање на стент во проксималниот сегмент на десцендентната торакална аорта. Истовремено, кај пациентот беше направен и двекратно аорто-коронарно премостување. Пациентот постоперативно беше стабилен, со задоволителен исход од интервенцијата. Дополнително, беше направен и ендоваскуларен третман на останатиот дел на торакалната аорта и на абдоминалните крвни садови. Меѓутоа, поради респираторно затајување, се постави во два наврати стент графт во левиот главен бронх. И покрај екстензивните напори, пациентот поради респираторна инсуфициенција имаше летален исход.

Заклучок: Навремената интервенција и мултидисциплинарниот пристап играа клучна улога во справувањето со компликациите, иако пациентот имаше летален исход поради мултиорганска слабост.

Клучни зборови: аортна патологија, аортна дисекција, аневризма на лакот, frozen elephant, trunk, хибриден третман, респираторна инсуфициенција, бронхијално стентирање