CASE REPORT

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Hybrid Management of a Giant Aortic Arch and Descending Thoracic Aortic Aneurysm Using Elephant Trunk Technique and Thoracic Endovascular Aortic Repair: A Case Report

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Abstract

Background: Extensive thoracic aortic aneurysms involving the aortic arch and descending thoracic aorta represent one of the most complex entities in cardiovascular surgery. Conventional open repair is associated with significant perioperative morbidity, especially in elderly patients with multiple comorbidities. Hybrid strategies combining open arch repair with staged endovascular treatment have emerged as a viable alternative in carefully selected patients.

Case Presentation: A 64-year-old hypertensive male with a chronic smoking history and chronic obstructive pulmonary disease presented with progressive dyspnoea. Imaging revealed giant aneurysmal dilatation of the aortic arch and descending thoracic aorta, along with an associated left common iliac artery aneurysm. A staged hybrid approach was planned. Stage I involved total arch replacement with deployment of an elephant trunk graft. Stage II consisted of thoracic endovascular aortic repair to exclude the descending thoracic aortic aneurysm. The postoperative course was complicated by prolonged ventilatory requirement necessitating tracheostomy and a transient generalized tonic–clonic seizure, both of which resolved with appropriate management. The patient recovered well and was discharged in stable condition.

Conclusion: This case illustrates that staged hybrid repair using the elephant trunk technique followed by TEVAR provides an effective and relatively safe treatment option for giant thoracic aortic aneurysms in high-risk patients. Careful patient selection, meticulous planning, and multidisciplinary management are essential for optimal outcomes.

Keywords: Aortic arch aneurysm; Descending thoracic aortic aneurysm; Elephant trunk technique; Hybrid aortic repair; TEVAR

Introduction

Thoracic aortic aneurysms constitute a significant proportion of aortic pathology and are associated with considerable morbidity and mortality if left untreated [1]. Aneurysms involving the aortic arch and descending thoracic aorta are particularly challenging due to their anatomical complexity, proximity to major supra-aortic vessels, and the need for cerebral and spinal cord protection during intervention [2].

Giant thoracic aortic aneurysms, though rare, carry a substantially increased risk of rupture, dissection, thromboembolism, and compressive symptoms involving the airway and esophagus [3]. Traditional open surgical repair remains the definitive treatment; however, it is associated with prolonged cardiopulmonary bypass, deep hypothermic circulatory arrest, and increased risk of neurological and respiratory complications, particularly in patients with advanced age or significant comorbid conditions [4].

The elephant trunk technique was developed to facilitate staged repair of extensive thoracic aortic disease

by creating a distal landing zone for subsequent intervention [5]. With the advent of thoracic endovascular aortic repair, hybrid strategies combining open arch replacement and endovascular exclusion of the descending thoracic aorta have gained widespread acceptance [6]. These approaches aim to reduce operative trauma while maintaining durable aneurysm exclusion. We report a detailed case of a giant aortic arch and descending thoracic aortic aneurysm managed successfully using a staged hybrid approach, highlighting diagnostic challenges, perioperative decision-making, postoperative complications, and outcomes in the context of contemporary evidence.

Case presentation

A 64-year-old male presented with gradually progressive dyspnoea on exertion over a period of several months. The dyspnoea was insidious in onset and had worsened to New York Heart Association functional class II–III at presentation. There was no associated orthopnoea or paroxysmal nocturnal dyspnoea. The patient denied chest pain, palpitations, syncope, hemoptysis, dysphagia, hoarseness of voice, or symptoms suggestive of cerebrovascular insufficiency. The patient had a long-standing history of systemic hypertension for more than 15 years, which was irregularly controlled on oral antihypertensive medications. He was a chronic smoker with a significant smoking history exceeding three decades. He was a known case of chronic obstructive pulmonary disease and was on regular inhaled bronchodilator therapy. There was no prior history of aortic surgery, connective tissue disorders, vasculitis, or traumatic chest injury. Family history was negative for aortic aneurysms, sudden cardiac death, or hereditary aortopathies.

On physical examination, the patient was conscious, oriented, and hemodynamically stable. Blood pressure recordings showed controlled systolic and diastolic values on admission. Oxygen saturation was mildly reduced on room air, consistent with underlying pulmonary disease. Cardiovascular examination revealed normal heart sounds without murmurs, rubs, or gallops. There were no signs of heart failure such as raised jugular venous pressure, peripheral edema, or hepatomegaly. Respiratory system examination demonstrated bilateral expiratory wheeze and prolonged expiratory phase, consistent with chronic obstructive pulmonary disease. Peripheral pulses were palpable and symmetrical in all extremities, with no evidence of limb ischemia or blood pressure differential.

Baseline laboratory investigations, including complete blood count, renal function tests, liver function tests, coagulation profile, and inflammatory markers, were within normal limits. There was no biochemical evidence of infection or systemic inflammatory disease. Arterial blood gas analysis showed mild hypoxemia without significant hypercapnia. A chest radiograph revealed marked widening of the mediastinum with abnormal aortic contour, raising suspicion of thoracic aortic pathology. Subsequently, contrast-enhanced computed tomography angiography of the chest, abdomen, and pelvis was performed for definitive evaluation. Imaging demonstrated a giant aneurysmal dilatation involving the aortic arch with extension into the descending thoracic aorta. The aneurysm was large enough to exert mass effect on adjacent mediastinal structures. The aortic arch branches were displaced but patent. No features of acute dissection, intramural hematoma, or contained rupture were identified. In addition, computed tomography angiography revealed an associated aneurysm of the left common iliac artery. The abdominal aorta and visceral branches were otherwise unremarkable.

Pulmonary evaluation confirmed moderate to severe chronic obstructive pulmonary disease, placing the patient at increased risk for prolonged mechanical ventilation following extensive open thoracic surgery. Cardiac evaluation did not reveal significant coronary artery disease or valvular pathology. Given the extensive involvement of the thoracic aorta, the size of the aneurysm, and the presence of significant pulmonary comorbidity, the case was discussed in detail in a multidisciplinary heart team meeting comprising cardiothoracic surgeons, vascular surgeons, anesthesiologists, cardiologists, pulmonologists,

and radiologists. Considering the high operative risk associated with a single-stage extensive open repair and the need to minimize physiological stress, a staged hybrid approach was deemed the most appropriate treatment strategy. The patient and family were counseled extensively regarding the nature of the disease, the planned staged hybrid repair, potential risks including neurological and respiratory complications, and the need for long-term surveillance. Written informed consent was obtained prior to proceeding with surgical intervention.

Management and Surgical Technique

Stage I: Total arch replacement with elephant trunk technique

Following comprehensive preoperative evaluation and multidisciplinary planning, the patient was taken up for elective open surgical repair. General anesthesia was administered with invasive hemodynamic monitoring, including arterial and central venous pressure monitoring. Neuromonitoring with near-infrared spectroscopy was employed to continuously assess cerebral oxygenation throughout the procedure. A standard median sternotomy was performed. After careful pericardial opening, cardiopulmonary bypass was established using central arterial and venous cannulation. Systemic cooling was initiated to facilitate cerebral protection. Selective antegrade cerebral perfusion was employed to maintain adequate cerebral blood flow during arch reconstruction. This strategy was chosen to minimize the risk of neurological injury while allowing safe replacement of the aortic arch.

Following cross-clamping and controlled circulatory arrest, the aneurysmal aortic arch was opened and excised. A prosthetic vascular graft was used to replace the aortic arch, with meticulous reconstruction of the supra-aortic vessels. An elephant trunk segment was intentionally deployed into the descending thoracic aorta and secured distally. This free-floating graft extension was positioned to provide a stable proximal landing zone for the planned second-stage endovascular intervention. Hemostasis was achieved carefully, and the patient was gradually rewarmed and weaned off cardiopulmonary bypass without hemodynamic instability. After satisfactory restoration of cardiac rhythm and stable cerebral oximetry readings, the sternum was closed in layers, and the patient was transferred to the cardiac intensive care unit for postoperative management.

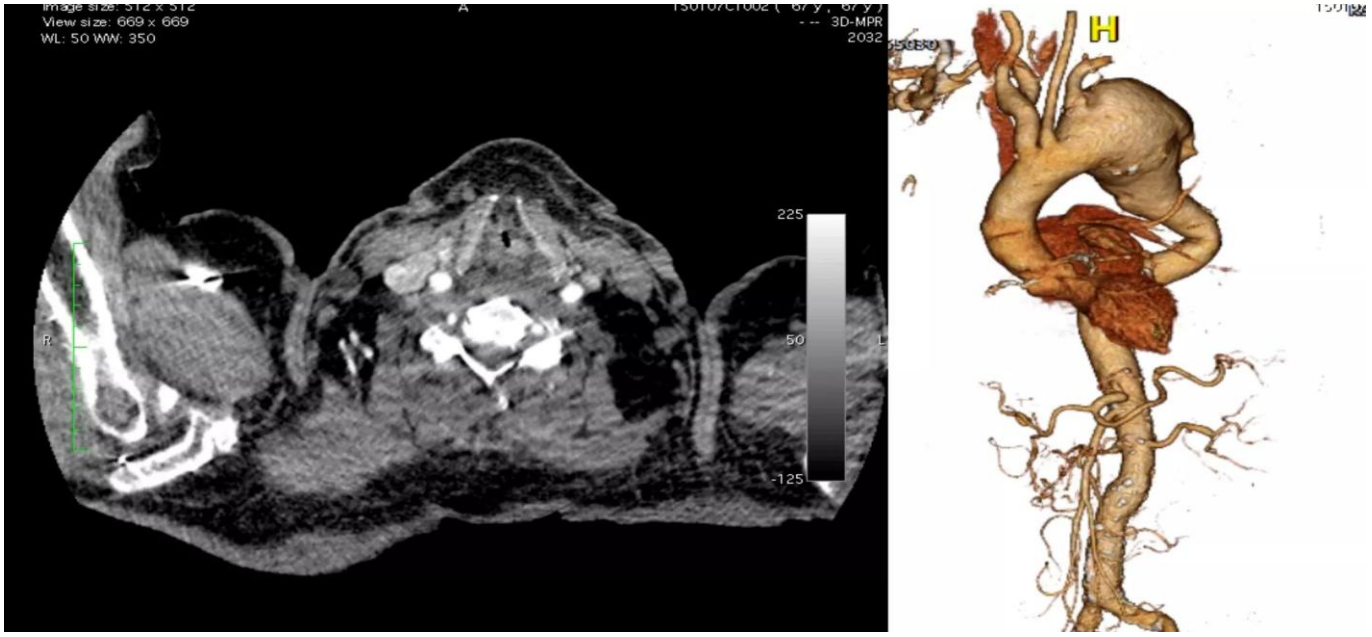

Figure 1: Imaging CT in Ascending & descending aorta

Postoperative course after stage I

The immediate postoperative period was notable for prolonged ventilatory dependence, attributed primarily to the patient's underlying chronic obstructive pulmonary disease and reduced pulmonary reserve. Despite aggressive pulmonary care and physiotherapy, extubation was not feasible in the early postoperative period, and a tracheostomy was performed to facilitate prolonged ventilatory support and gradual weaning. During the postoperative recovery phase, the patient experienced a transient generalized tonic–clonic seizure. Urgent neurological assessment was undertaken. Computed tomography of the brain did not reveal any evidence of acute ischemia, intracranial hemorrhage, or space-occupying lesion. Electrolyte abnormalities were excluded. The seizure was managed with antiepileptic medication, following which no further seizure activity was observed. The patient remained neurologically intact on serial examinations. Gradual clinical improvement was noted over the subsequent days, with stabilization of respiratory parameters and hemodynamic status. After successful ventilator weaning through the tracheostomy, the patient was transferred to the step-down unit. Once adequate recovery from the first stage was achieved, he was reassessed for completion of the second stage of repair.

Stage II: Thoracic endovascular aortic repair

After an interval of clinical stabilization, the patient underwent the planned second-stage thoracic endovascular aortic repair. The procedure was performed under fluoroscopic guidance. Vascular access was obtained, and angiographic evaluation confirmed appropriate positioning and patency of the previously deployed elephant trunk graft. A thoracic stent graft was advanced and deployed with the elephant trunk serving as the proximal landing zone. Care was taken to ensure optimal alignment and complete coverage of the aneurysmal segment of the descending thoracic aorta. Completion angiography demonstrated successful exclusion of the aneurysm with no evidence of endoleak, graft migration, or compromise of major branch vessels. The procedure was well tolerated, and the patient was transferred to the intensive care unit for routine post-endovascular monitoring.

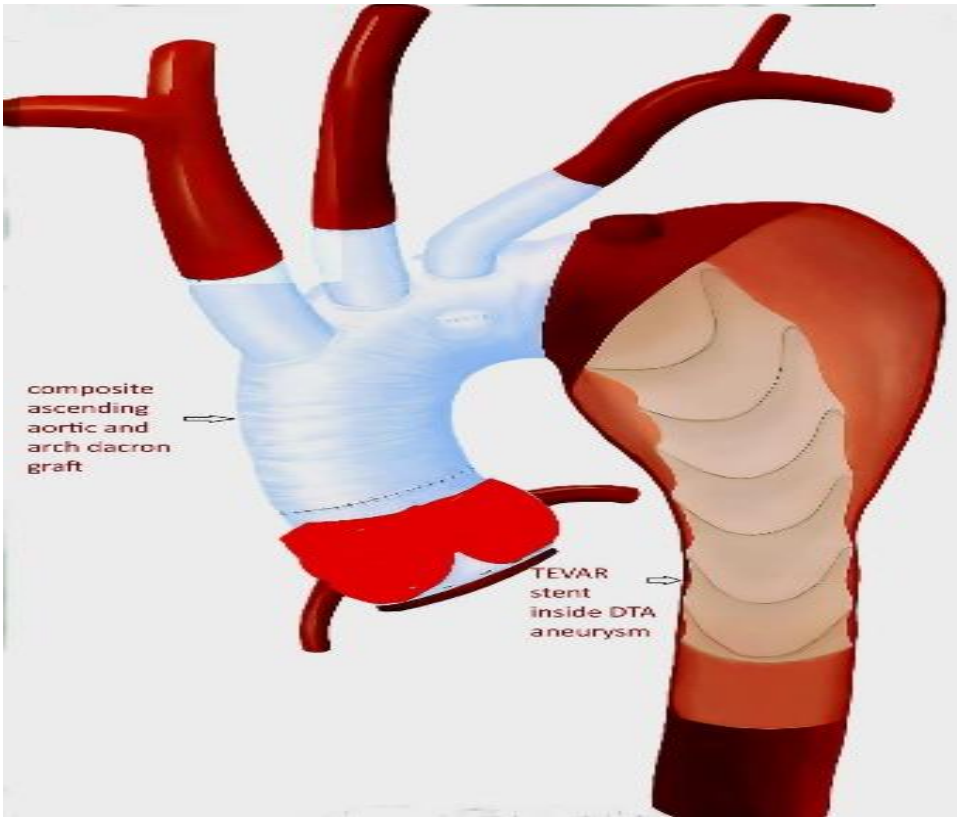

Figure 2: Hemiarch and Innominate Artery Reconstruction

Outcome and follow-up

Following the second stage of repair, the patient demonstrated steady clinical improvement. Respiratory function improved significantly, allowing gradual downsizing and eventual decannulation of the tracheostomy. The patient remained neurologically stable, with no recurrence of seizures or focal deficits. Postoperative imaging using contrast-enhanced computed tomography angiography confirmed satisfactory positioning of both the surgical graft and the endovascular stent graft. The aortic arch and descending thoracic aorta were effectively excluded from circulation, with no evidence of endoleak, graft kinking, or distal malperfusion.

The patient was discharged in stable condition with advice for strict blood pressure control, continuation of bronchodilator therapy, complete smoking cessation, and regular follow-up. A structured surveillance plan was instituted, including periodic clinical evaluation and serial imaging to monitor graft integrity and detect any late complications. At follow-up, the patient remained asymptomatic with good functional recovery, highlighting the effectiveness of the staged hybrid approach in managing extensive thoracic aortic aneurysms in high-risk individuals.

Discussion

Giant aneurysms involving the aortic arch and descending thoracic aorta represent one of the most complex and high-risk entities in thoracic aortic surgery. Their management requires careful assessment of aneurysm morphology, patient comorbidities, and procedural risk. The present case illustrates the successful application of a staged hybrid strategy in a patient with significant pulmonary comorbidity, highlighting contemporary principles in the management of extensive thoracic aortic disease.Thoracic aortic aneurysms often remain clinically silent until they reach a critical size or produce compressive symptoms. Large aneurysms involving the aortic arch and descending thoracic aorta are associated with a substantially increased risk of rupture, dissection, thromboembolism, and sudden death. Johnston and Soltesz [7] emphasized that giant thoracic aneurysms carry particularly poor natural history outcomes and warrant timely elective intervention. Involvement of the arch further increases complexity due to the need for cerebral protection during surgical repair.

These risks are amplified in patients with advanced age or significant systemic comorbidities. Bavaria et al. [8] demonstrated that hybrid arch repair strategies significantly reduce operative mortality and neurological complications in appropriately selected high-risk patients. Similarly, Shrestha et al. [9] reported favorable early and mid-term outcomes with staged hybrid approaches compared to extensive open reconstruction.

In the present case, the presence of chronic obstructive pulmonary disease and limited pulmonary reserve made a single-stage open repair particularly hazardous. A staged hybrid approach was therefore chosen to minimize physiological stress while achieving effective aneurysm exclusion. By creating a free-floating graft segment within the descending thoracic aorta during arch replacement, it facilitates subsequent distal repair and reduces manipulation of aneurysmal tissue. Phan et al. [10] highlighted the continued relevance of the elephant trunk technique in the modern era, particularly in combination with endovascular technology. The availability of thoracic endovascular aortic repair has further enhanced the utility of this technique by allowing less invasive completion of distal aneurysm exclusion, as demonstrated by Moulakakis et al. [11].

Neurological injury remains one of the most feared complications of aortic arch surgery. Advances in cerebral protection strategies, including selective antegrade cerebral perfusion and continuous neuromonitoring, have significantly reduced the incidence of permanent neurological deficits. Etz et al.

[12] emphasized that optimized cerebral protection is critical in reducing stroke and cognitive dysfunction following arch surgery. The transient generalized tonic–clonic seizure observed in the present patient underscores the neurological vulnerability associated with complex aortic procedures. Importantly, neuroimaging revealed no structural brain injury, and the episode resolved completely with medical management. Werner and Czerny [13] reported that transient neurological events may occur after hybrid aortic repair and do not necessarily correlate with permanent cerebral injury when promptly recognized and treated.

Recent evidence supports the use of staged hybrid repair in selected patients with extensive thoracic aortic aneurysms. Krishnan et al. [15] reported acceptable early mortality and reduced neurological complications following staged hybrid thoracic aortic repair. Comparative studies by Yamabe et al. [16] demonstrated that limited arch replacement combined with endovascular completion is associated with shorter operative times and comparable mid-term outcomes when compared with more extensive open procedures.

Successful management of extensive thoracic aortic disease requires a multidisciplinary approach involving cardiothoracic surgeons, vascular surgeons, anesthesiologists, intensivists, pulmonologists, and radiologists. Akintoye et al. [17] emphasized that outcomes of complex thoracic aortic surgery are significantly improved in high-volume centers with coordinated multidisciplinary care. Long-term surveillance is equally critical, as late complications such as endoleaks, graft migration, or disease progression in untreated segments may occur. Borger et al. [18] highlighted the importance of lifelong imaging follow-up and aggressive risk factor modification following thoracic aortic interventions.

Limitations: This report represents a single-case experience and therefore, may not be generalizable to all patients with extensive thoracic aortic aneurysms. Outcomes are influenced by patient selection, anatomical complexity, and institutional expertise. Nevertheless, the case provides valuable insight into contemporary hybrid management strategies for high-risk patients.

Summary

This case report describes the successful staged hybrid management of a giant aortic arch and descending thoracic aortic aneurysm in a high-risk patient with significant pulmonary comorbidity. The patient underwent elective total arch replacement with deployment of an elephant trunk graft, followed by thoracic endovascular aortic repair to exclude the descending thoracic aortic aneurysm. Despite postoperative respiratory and transient neurological complications, timely multidisciplinary management resulted in complete recovery and effective aneurysm exclusion. This case highlights the importance of individualized treatment planning, the role of the elephant trunk technique in facilitating staged repair, and the value of hybrid strategies in reducing operative risk while maintaining durable outcomes in complex thoracic aortic pathology.

Conclusion

Giant aneurysms involving the aortic arch and descending thoracic aorta present substantial surgical challenges, particularly in patients with significant comorbidities. This case demonstrates that a staged hybrid approach combining total arch replacement with the elephant trunk technique and subsequent thoracic endovascular aortic repair can be performed safely and effectively in carefully selected patients. Meticulous preoperative planning, advanced cerebral protection strategies, proactive management of respiratory complications, and coordinated multidisciplinary care are essential for favorable outcomes. Lifelong imaging surveillance and aggressive risk factor modification remain critical to ensure long-term graft durability and prevent late complications following hybrid thoracic aortic repair.

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