A multidisciplinary multistage complete mega aorta replacement and utilization of extracorporeal membrane oxygenation in thoracoabdominal aneurysm repair

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ABSTRACT

A 49-year-old woman underwent a 11-month multistage complete replacement of a mega aorta. Replacement stages included ascending aorta and arch replacement in conjunction with a frozen elephant trunk thoracic endovascular aortic repair, extension of thoracic endovascular aortic repair to zone 5, and open repair of the thoracoabdominal aneurysm with the use of venoarterial extracorporeal membrane oxygenation for circulatory support. This case illustrates the complexity of repairing a mega aorta, the multidisciplinary care and staging needed for repair, and the use of peripheral venoarterial extracorporeal membrane oxygenation for circulatory perfusion during thoracoabdominal aneurysm repair. (J Vasc Surg Cases Innov Tech 2023;9:101190.)

Keywords: Mega aorta; Thoracoabdominal aortic aneurysm; Thoracoabdominal aortic repair; Hybrid aortic repair; Extracorporeal membrane oxygenation (ECMO)

We report a case of mega aorta type III[1] replacement and the use of venoarterial extracorporeal membrane oxygenation (VA-ECMO) during the thoracoabdominal aortic aneurysm (TAAA) repair. The patient provided consent for publication.

CASE REPORT

A never-smoker 49-year-old woman was referred with a 5.5-cm extent II TAAA and ascending aorta and arch aneurysms consistent with a type III mega aorta syndrome (MAS) (Fig 1, *A-D*). She had a history of hypertension and no syndromic features or family history associated with genetic aortopathy. The patient's care plan was discussed at our multidisciplinary thoracic aortic program conference attended by vascular and cardiac surgery, cardiology, and medical genetics. Preoperative workup included cardiac and pulmonary risk assessment and aortopathy genetic testing which was negative. She underwent a planned four-stage open surgical replacement of the entire aorta over 11 months.

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The first stage was a left subclavian to carotid artery transposition performed as a separate procedure. The second stage was an ascending aortic and zone 2 arch replacement with antegrade thoracic endovascular repair (TEVAR) 28 × 150 mm Gore cTAG stent graft (W. L. Gore & Associates, Flagstaff, AZ) to zone 4 frozen elephant trunk (Fig 2, *A*). The third stage was TEVAR extension into zone 5 using a 32 × 28 × 201 Cook Alpha stent graft (Cook Medical, Bloomington, IN) (Fig 2, *B*) converting the patient's TAAA extent from type II to III. This device is chosen because of the active fixation feature and the fabric can be transected between the Z stents thus the length can easily be adjusted as needed intraoperatively during the open TAAA repair.

Last, she underwent open extent III repair. A prophylactic cerebrospinal fluid (CSF) drain was placed. The TAAA was exposed via the sixth intercostal space thoracoabdominal incision. A custom Dacron graft was created using a 24 × 12-mm bifurcated graft for the distal portion with two 14 × 7-mm bifurcated grafts anastomosed to the main body as conduits for the renal arteries, superior mesenteric artery (SMA), and the ECMO arterial cannula. The patient was heparinized to an activated clotting time (ACT) of 250 seconds. Repair started with the infrarenal abdominal aorta and iliac arteries reconstruction in a bottom-up manner with a clamp placed across the aneurysmal infrarenal aorta. This technique allowed for native in-line visceral perfusion for this portion of the procedure. The inferior mesenteric and lumbar arteries had excellent back bleeding and were ligated. Once completed, the graft was clamped and a 25F Bio-Medicus ECMO venous sheath was placed in the right atrium via the left femoral vein. A 20F Edwards Fem-Flex II cannula was used for arterial cannulation into

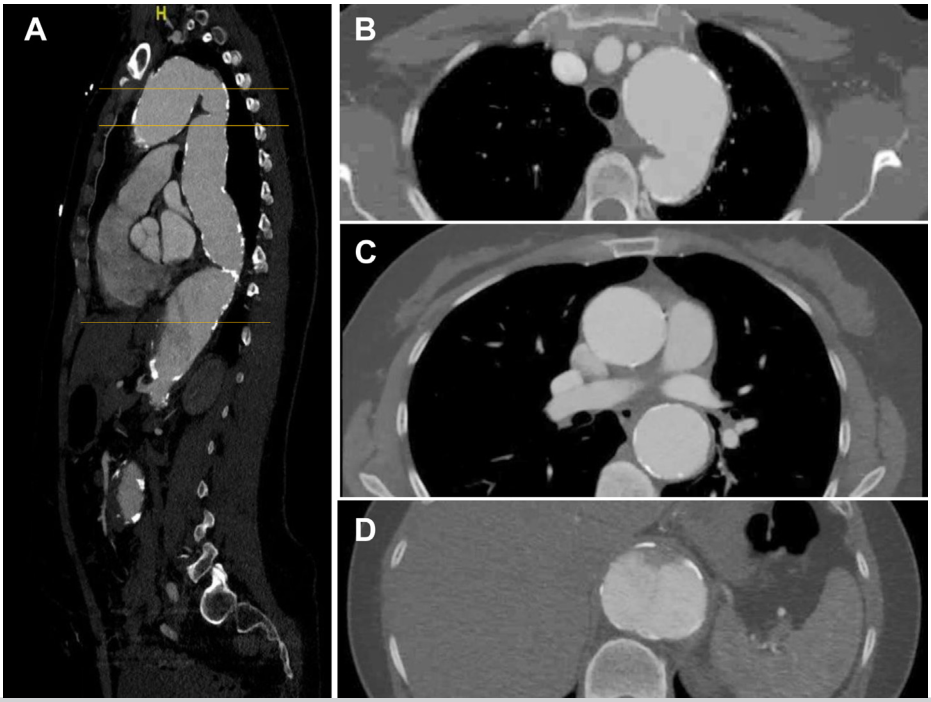

Fig 1. Preoperative coronal computed tomography imaging of a type III mega aorta demonstrating the diffuse aneurysmal dilation from the aortic valve to the iliac bifurcation **(A)** with axial imaging at the level of the arch **(B)**, the ascending and descending thoracic aorta **(C)**, and supraceliac aorta **(D)**.

one of the 7-mm Dacron graft limbs. The VA-ECMO centrifugal circuit maintained femoral mean pressure at 60 mm Hg. The mean central arterial pressure was maintained at 90 mm Hg, and CSF was drained at 10 mL/h throughout the case. The left renal and SMA were sequentially anastomosed to the respective graft limbs by ligating the origin, transecting the artery, and preforming the anastomosis, thus minimizing any ischemic time beyond what was needed to perform the anastomosis. A separate 7-mm graft was anastomosed to SMA limb to provide the celiac artery conduit. A proximal aortic cross clamp was then placed at the level of T6 and T7 and aortotomy preformed. Back bleeding intercostal arteries were oversewn, and the right renal artery was anastomosed to the remaining limb. Next, the aorta was clamped at zone 3 and transected at the level of the distal end of the indwelling TEVAR graft. The proximal anastomosis was performed between a 28-mm Dacron tube graft and the aortic aneurysm sac-TEVAR junction with circumferential felt placed between the stent and the aorta. Finally, the 28- and 24-mm grafts were anastomosed graft to graft, and antegrade flow restored. The ECMO circuit was weaned, heparin reversed, and the ECMO Dacron limb was transected with a GIA stapler. The total ECMO time was 107 minutes, estimated blood loss 4000 mL, and operative time was 7 hours. Total transfusions included 2100 mL packed red blood cells, 2687 mL fresh frozen plasma, and 619 mL platelets. The patient was extubated the following morning and discharged 12 days postoperatively with normal renal function and no spinal cord injury. The patient continues to do well 6 months after repair (Fig 2, *C*)

DISCUSSION

This case illustrates three points: the importance of providing multidisciplinary care for patients with MAS, that this type of repair takes time and planning, and the successful use of VA ECMO in open TAAA repair allowing staged clamping of the aorta and minimizing end organ ischemic time.

MAS is rare and requires complex multistage repair of the ascending aorta, arch and TAAA.[2-4] Open repair of the ascending aorta and arch includes an frozen elephant trunk component (conventional or TEVAR). The residual extent II TAAA repair can be open or via a hybrid approach that includes abdominal aortic debranching, or total endovascular repair with branched endografts.[3,4] Ultralong durability of branched endografts remain under investigation, with 23% of cases requiring secondary interventions.[4-6] A particular hybrid repair worth noting is the Lupiae technique. This technique involves replacing the ascending aorta and arch with a multibranched Dacron graft to reroute the great vessels origins close to the sinotubular junction and creates a proximal Dacron landing zone at the distal

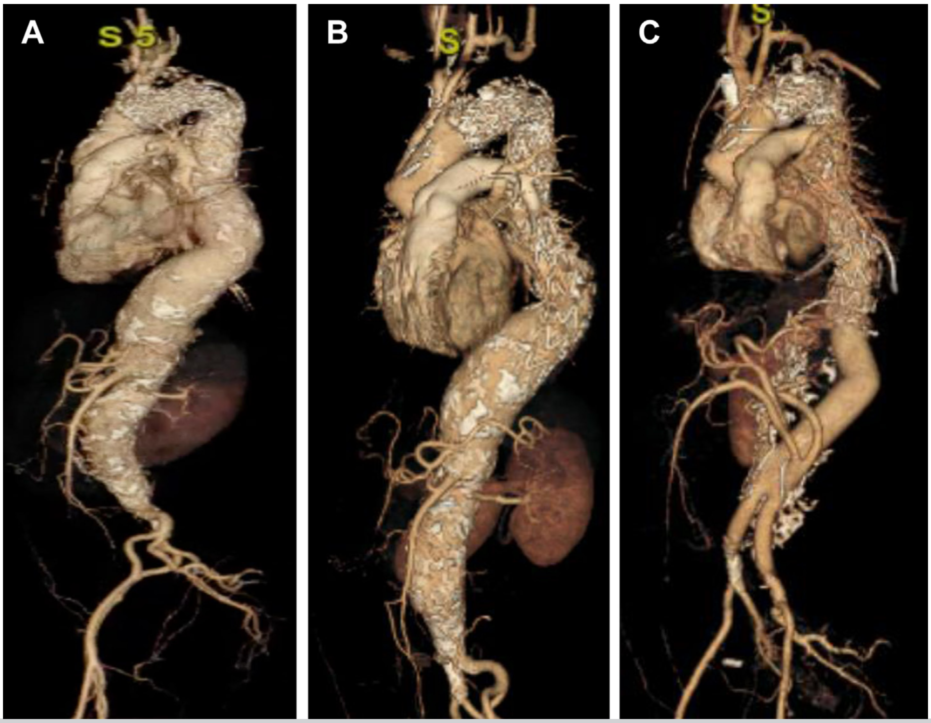

Fig 2. A three-dimensional postprocessing computer tomography image of the type III mega aorta after ascending and arch repair with frozen elephant trunk thoracic endovascular aortic repair (TEVAR) **(A)**, then post extension of the TEVAR to zone 5 **(B)** and post complete aortic replacement **(C)**.

ascending aorta. This step is followed by a second stage of infrarenal abdominal aorta replacement and visceral arteries debranching. After recovery, a TEVAR is placed landing proximally and distally in the existing Dacron grafts.[1] In our case, the patient was young and open repair was the most durable repair option. Although she underwent open aortic repair, we leveraged TEVAR to convert a TAAA extent II to III repair, thus allowing a lower level of thoracotomy. The recovery time between stages ensured optimal outcomes with each staged repair.

Maintaining end-organ perfusion during TAAA repair is key to minimizing perioperative complications. Prophylactic CSF drain placement, sequential aortic clamping, and intraoperative extracorporeal bypass are recommended.[4,7-11] Traditionally, extracorporeal bypass is provided using left heart bypass (LHB) or full cardiopulmonary bypass (CPB) techniques. In LHB, the drainage venous cannula is placed in the left atrium via the left inferior pulmonary vein and oxygenated blood is run through a centrifugal pump with then returned via the systemic circulation.[11,12] When the descending thoracic aorta is clamped, the bypass circuit provides flow to the lower extremities and the heart provides flow for the head and upper extremities.[7,11] Cold blood via the cardioplegia system is used for selective visceral perfusion (if using a system with a venous reservoir). Other variations include splitting the LHB return line via a Y-connector between the common femoral artery cannula and another line for selective visceral perfusion, and/or renal arteries supplied with 4°C cold renal solution.[4,11,12] If using a LHC or CPB with venous reservoir full heparinization is required with an ACT of >480 seconds.

Like LHB, in VA-ECMO the deoxygenated blood from the right atrium is drained via the venous cannula, run through a centrifugal pump, an oxygenator, and inline heat exchanger, and is returned typically via the common femoral artery. However, VA ECMO offers two advantages over LHB and CPB during TAAA repair: (1) A lower systemic heparinization/ACT goal of 180 to 250 seconds[12,13] and (2) the absence of a reservoir needed for pump suckers, which are powered with a roller head; thus, there is no air-blood contact and a theoretically decreased associated inflammatory reaction. These two advantages translate to a potentially lower intraoperative blood loss and a decreased risk of acute respiratory distress syndrome owing to lower inflammatory mediator release.14 Another potential benefit is rapid transition to CPB should a need for circulatory arrest arise. The use of the bottom-up approach allowed us to preform sequential clamping and repair of the aorta starting with the infrarenal portion then placing the patient on VA-ECMO followed by sequential visceral revascularization, further reducing organ ischemic times.

Our case adds to the growing body of literature on the use of intraoperative VA-ECMO in vascular surgery which includes three other cases: an open extent II TAAA repair in an 82-year-old man and two open abdominal aortic aneurysm repairs.[15,16]

CONCLUSIONS

MAS is a complex aortic pathology requiring multistage complex aortic repair. VA-ECMO is an effective tool for providing perfusion during TAAA repair. Further studies exploring the intraoperative use of VA-ECMO in TAAA repair are warranted.

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