Hybrid repair of type II thoracoabdominal aortic aneurysm using modified branch-first technique

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ABSTRACT

The hybrid modified branch-first technique has extended the feasibility of open thoracoabdominal aortic aneurysm (TAAA) repair in otherwise hostile aortic anatomy that is not entirely amenable for extent II open TAAA conventional repair or total endovascular repair. The modified branch-first open TAAA technique has been developed successfully at our center and has been used to treat extent III TAAAs with successful outcomes. By combining the modified technique with endovascular thoracic aortic repair, we have been able to successfully extend its use to more extensive extent II TAAAs. This could prove to be a useful technique in the armamentarium of aortic surgeons. (J Vasc Surg Cases Innov Tech 2023;9:1-5.)

Keywords: Thoracoabdominal aortic aneurysm; TAAA repair; Modified branch-first technique; Aortic surgery

Hybrid repair of thoracoabdominal aortic aneurysms (TAAAs) has significantly broadened the treatment options for complex aortic pathologies with the aim of minimizing the morbidity and mortality.[1] We previously reported the use of the novel modified branch-first technique to treat type III TAAAs during open repair, which significantly helped to reduce the risk of perioperative visceral ischemia and bleeding. The procedure was performed without cardiopulmonary bypass.[2] In the present case, we have combined this technique with a hybrid repair to treat a type II TAAA. The patient provided written informed consent for the report of his case details and imaging studies.

CASE REPORT

A 73-year-old man with a history of chronic type B aortic dissection had presented with recent onset of back pain. A type II TAAA measuring 5.1 cm in the thoracic descending aorta and maximum of 6 cm in the abdominal aorta was found. The aortic aneurysm was not amenable to either a custom-made branched endo—endograft or an off-the-shelf graft owing to the limited availability in the region during the COVID-19 (coronavirus disease 2019) crisis. The patient was scheduled for zone II thoracic endovascular aneurysm repair with left subclavian artery bypass, followed by open repair of the TAAA using a modified debranch-first technique.

SURGICAL TECHNIQUE

First stage. In the first stage, the patient underwent left carotid to left subclavian artery bypass using an 8-mm Dacron graft via a left supraclavicular incision (Fig 1, *A*). In the same setting, a zone II thoracic endovascular aneurysm repair was performed using a 32 × 32 × 196-cm Talent thoracic endograft (Medtronic, Dublin, Ireland), which was extended with a 34 × 34 × 150-cm TAG device (W.L. Gore & Associates, Flagstaff, AZ) deployed distally to land 4 cm above the celiac artery (Fig 1, *B*). The completion angiogram confirmed excellent flow through the debranched distal aortic arch and descending aortic stent graft. The patient had had an uneventful recovery within 7 days.

Second stage—modified branch-first technique. After the first stage, the patient had undergone second-stage open thoracoabdominal aortic repair. After insertion of a lumbar spinal drain, the patient was positioned in the right lateral decubitus position with a semitilt of his pelvis. The thoracic aorta was exposed after circumferential division of the diaphragm, followed by retroperitoneal exposure of the abdominal aorta and its visceral branches. The celiac artery, superior mesenteric artery, and left renal artery were dissected at their origin and exposed for a length of 3 to 4 cm (Fig 1, *C*) using laparoscopic dissection cautery. Overestimating the length of the graft limbs could lead to kinking and thrombosis of the visceral arteries.

The left atrium was accessed by opening the pericardium just adjacent to the thoracic aorta. After

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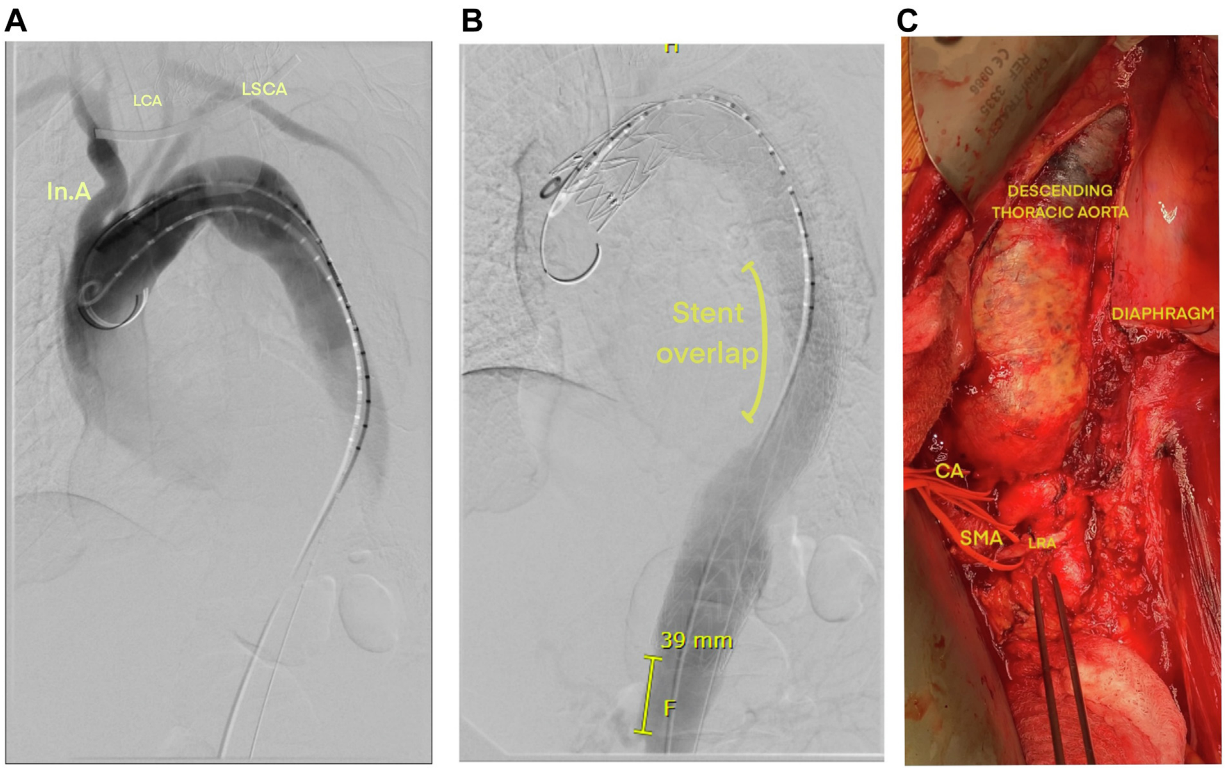

Fig 1. **A,** Angiogram showing first-stage thoracic endovascular aneurysm repair and left carotid to left subclavian artery bypass. **B,** Thoracic stent graft deployed ~4 cm above celiac artery origin. **C,** Thoracoabdominal aorta exposed and visceral arteries dissected and looped. The diaphragm was circumferentially divided. The onset of thrombosis can be seen in the descending aorta after thoracic aortic stent graft placement. *CA,* Celiac artery; *LRA,* left renal artery; *SMA,* superior mesenteric artery.

heparinization (activated clotting time, 250-300 seconds), the left atrium was cannulated using a 24F, single-stage venous cannula and connected to the left heart bypass (LHB) circuit to form the outflow. The other end of the circuit was connected to one of the limbs of a Coselli thoracoabdominal branched graft, which served as the inflow for visceral perfusion. The pressurized graft was positioned parallel to the visceral aorta (Fig 2), and each branch was anastomosed sequentially (Fig 3, *A*). Continuous visceral perfusion was maintained after each anastomosis. After completion of the visceral anastomoses, the descending aorta with the stent graft was directly anastomosed to the proximal Dacron graft (Fig 3, *B*). The infrarenal aorta was clamped and the aortic aneurysm opened (Fig 3, *C*). The right renal artery was identified and flushed with 1 L of cold Ringer's lactate solution. The right renal artery ostium was anastomosed to the thoracoabdominal aortic (TAA) graft (Fig 3, *D*). Several lumbar arteries were noted to arise from the infrarenal aorta below the clamp; thus, no spinal arteries were reimplanted onto the aortic graft. The clamp was moved distally on the graft to just below the right renal branch, and the distal end-to-end aortic anastomosis was completed in a standard fashion. The visceral

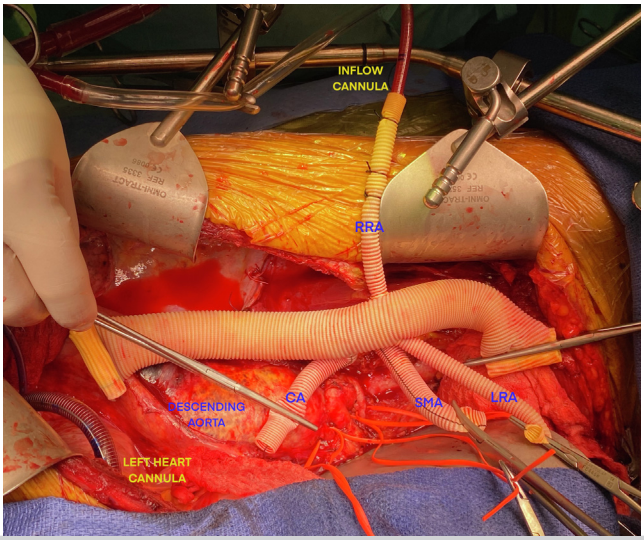

Fig 2. The pressurized thoracoabdominal graft was laid parallel to the exposed thoracoabdominal aneurysm of the aorta. All three limbs were clamped, ready to be sequentially anastomosed. The right renal artery (*RRA*) limb received inflow via the left heart bypass (*LHB*) by cannulating the left atrium. *CA,* Celiac artery; *LRA,* left renal artery; *SMA,* superior mesenteric artery.

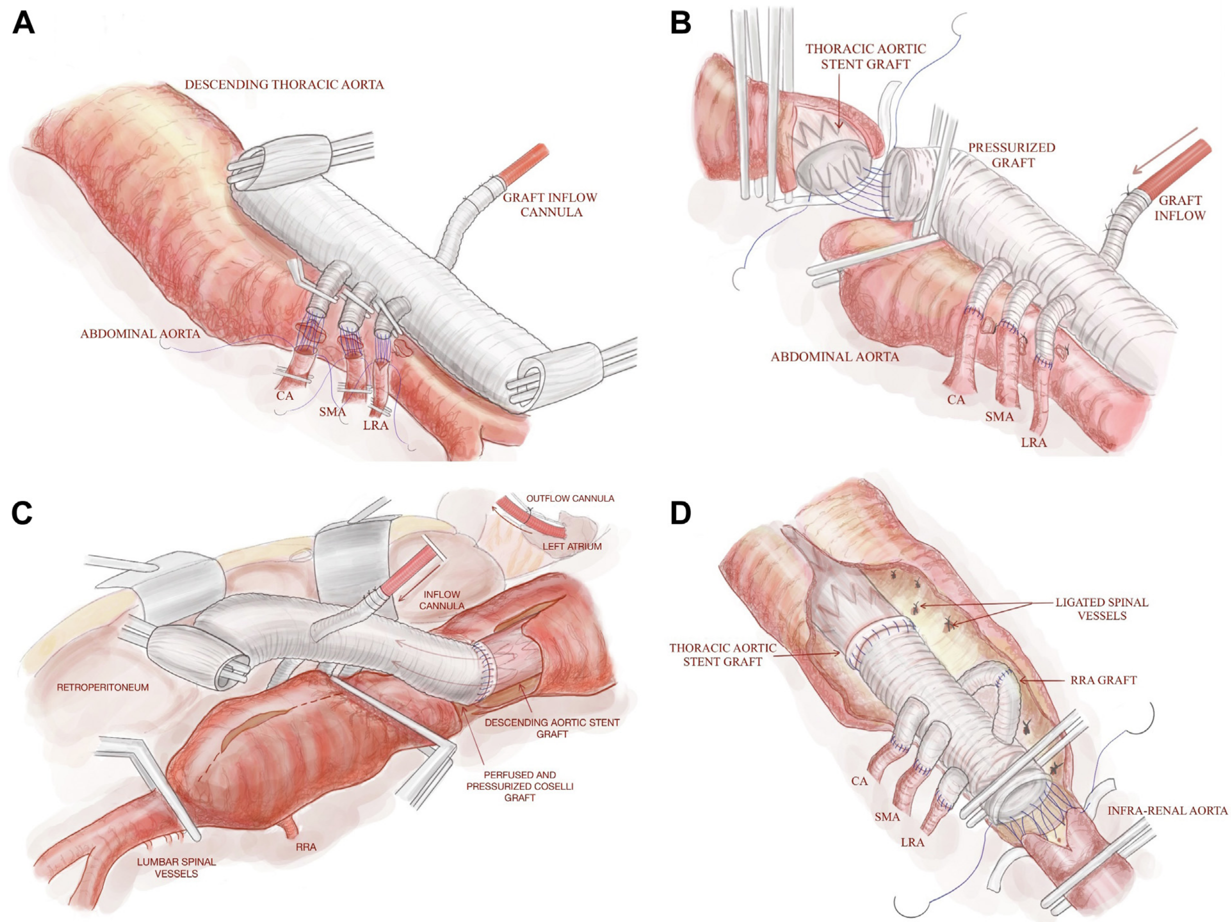

Fig 3. Important sequence of steps of modified branch-first thoracoabdominal aortic aneurysm (TAAA) technique. **A,** Sequential debranching of celiac artery (*CA*), superior mesenteric artery (*SMA*), and left renal artery (*LRA*). The thoracoabdominal graft was perfused via the right renal artery (*RRA*) limb (inflow) connected to the left heart bypass (*LHB*) circuit. **B,** Proximal stent graft to Dacron graft anastomosis performed by clamping the aneurysmal aorta, with subsequent antegrade aortic graft perfusion restored. **C,** The aneurysm was opened and the RRA exposed from within the aneurysmal sac. **D,** Final distal aortic anastomosis completed after the RRA anastomosis.

arteries continued to receive pulsatile flow while the distal aortic anastomosis was completed. Adequate hemostasis was achieved, the diaphragm reconstructed, and the thoracoabdominal wound closed in standard fashion.

Perfusion circuit. The perfusion circuit was set up by combining a LHB circuit and conventional cardiopulmonary bypass circuit (CPB; Fig 4). The LHB was used primarily to conduct this procedure. The difference between the currently used LHB circuits and this modification was that the inflow was connected to the thoracoabdominal graft to provide visceral perfusion via the pressurized TAA graft. A "Y" limb can be connected for lower body circulation if needed. The roller pump was used to regulate the amount of blood flow to the viscera at various stages of the debranching. However, if we encountered difficulties with hemodynamics or exposure, full CPB could be instituted with or without hypothermia.

RESULTS

The patient was extubated shortly after his arrival at the intensive care unit. The cerebrospinal fluid pressure was maintained in accordance with the protocol.[3] No evidence was found of significant visceral malperfusion in the postoperative period. On postoperative day 2, he was found to have bilateral thigh muscle weakness. Spinal cord ischemia correction measures were instituted, and an appropriate workup was performed. The lower limb weakness had gradually improved over 4 weeks. He was discharged to a rehabilitation facility after 15 days. Computed tomography angiography at 1 month showed successful repair of the type II TAA without an endoleak or malperfusion (Fig 5). At 1 year of follow-up, the patient was ambulating independently with the help of a walker.

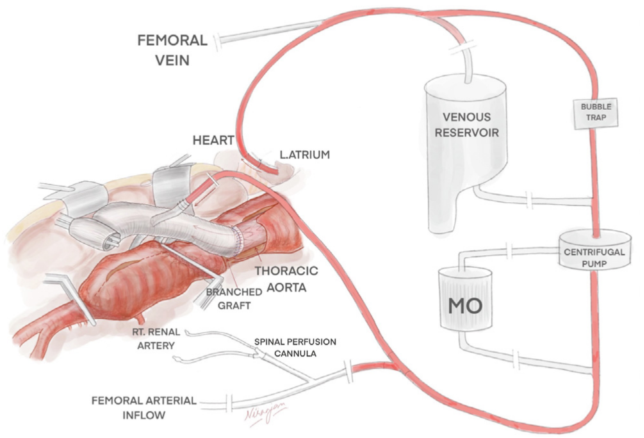

Fig 4. The modified left heart bypass (*LHB*) circuit connected in parallel to a full cardiopulmonary bypass (*CPB*) circuit. In the case of full CPB, the venous inflow can be derived from percutaneous femoral vein cannulation using a two-stage venous cannula. Spinal artery perfusion can be maintained using a self-inflating ostial cannula derived from the bypass circuit. *MO,* Membrane oxygenator; *RT.,* right.

DISCUSSION

The current open thoracoabdominal aortic repair techniques have a reported mortality rate in the range of 5% to 25%.[4,5] Some of the challenges faced during extensive open aortic repair have included extensive blood loss, the risk of visceral ischemia after aortic cross-clamping, and spinal cord ischemia.[6,7] The entire procedure must be performed rapidly and precisely by experienced aortic surgeons to minimize morbidity and successfully manage the extensive back bleeding from the visceral and spinal arteries. Large volume centers that routinely perform TAAA surgeries have reported excellent results, which have often been difficult to mimic.[8] The on-pump "branch-first" technique has been previously described for aortic arch replacement and TAAA repair using a separate smaller branched graft by Matalanis and Ch'ng.[9] In our reported modification of the branch-first technique, we derived graft inflow from an undiseased portion of the descending aorta. In the present patient, owing to the presence of an endograft in the descending aorta, an alternative inflow was required to

Fig 5. Preoperative computed tomography scan showing entire thoracoabdominal aortic aneurysm (TAAA). The thoracic aortic measured 5.0 cm, the mid-thoracic aorta measured 4.7 cm, and the abdominal aorta measured 6 cm. Postoperative computed tomography angiogram depicting extent II TAAA hybrid repair with well-positioned branched thoracoabdominal aortic (TAA) graft.

provide continuous visceral perfusion. Therefore, left heart cannulation was preferred. The length of the graft branches was estimated after setting the graft on the native aorta aligned with the visceral branches. Anastomosing the visceral arteries first and sequentially helped to prevent blood loss from the back bleeding vessels and improved the visibility. For the present patient, we were able to provide uninterrupted visceral perfusion and conduct the entire operation without the need for full CPB or hypothermia of the beating heart.

The two stages of TAAA repair should be adequately spaced to allow for adequate spinal collateralization. Although our patient had adequate lumbar collateral vessels, he developed paraparesis, probably due to the short timing between the two stages and the extent of aortic coverage required.

CONCLUSIONS

The described hybrid approach has extended the indication for patients who will benefit from the modified branch-first technique's significant reduction in blood loss and uninterrupted blood flow to the visceral organs. These patients have a low physiologic reserve to tolerate CPB and anatomy not amenable to total endovascular repair. Patient selection and preoperative multidisciplinary planning remains imperative for successful outcomes.

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