A technique for a single-stage off-pump repair of Kommerell diverticulum with antegrade branch vessel reconstruction

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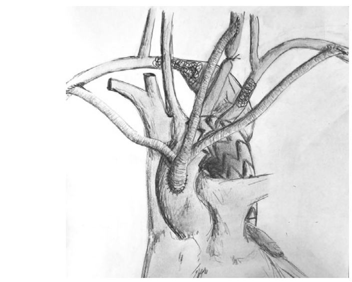

Single-stage hybrid technique for off-pump management of Kommerell diverticulum.

CENTRAL MESSAGE

Kommerell diverticulum (KD) repair techniques are not standardized. We present a single-stage off-pump technique that provides KD repair with antegrade and multiple-inflow head vessel reconstruction.

Kommerell diverticula (KD) are uncommon. When a KD is identified, repair is indicated if symptomatic or if interval growth is demonstrated. Because of their rarity, no standardized technique has been established. Approaches reported have various limitations that include multiple operative stages, need for cardiopulmonary bypass (CPB) or circulatory arrest, or reconstruction of arch branches with retrograde flow, and at times relying on a single inflow. The technique presented addresses most of these limitations.

CASE PRESENTATION

A 52-year-old female patient presented with 2 weeks of persistent chest pain. Workup for coronary disease was negative, and a computed tomogram of the chest revealed a posteriorly emanating 52-mm KD giving rise to a 34-mm aberrant right subclavian artery (ARSA). The left subclavian artery arose at the same aortic level and just anterior to the circumference of the KD. The left common carotid artery (LCCA) ostium was only 3 mm proximal to the KD (Figure 1, *A* and *B*). Given the otherwise-unexplained pain and the size of the aneurysms, intervention was recommended. Institutional review board approval was not required (technique manuscripts did not meet the Department of Health and Human Services definition of "research"). The patient provided informed written consent.

TECHNIQUE

A 2-cm incision was made at the anterior border of the left sternocleidomastoid and the LCCA was exposed in the standard fashion with care to avoid the vagus nerve. Three-centimeter incisions were made bilaterally to expose the axillary arteries in the deltopectoral grooves, with care to avoid the brachial plexus. Ultrasound-guided femoral artery access was obtained bilaterally, and 6-Fr sheaths were inserted.

An upper hemisternotomy was made into the right third intercostal space. The thymus was dissected, and the pericardium was opened and suspended. The aorta was dissected from the main pulmonary artery, as well as minimally dissected from the innominate vein.

A trifurcated graft was fashioned by sewing a 10-mm graft (Hemashield Gold) into the inflow of a bifurcated 16 × 8 × 8-mm graft (Hemashield Gold) to create a trifurcated graft with a beveled inflow of about 20 mm and 3 outflows: two 8-mm and one 10-mm branch. Heparin was given, and activated clotting time was confirmed to be >250 seconds. An appropriately sized ellipse of the ascending aorta was marked, and an aortic side-biting clamp was applied as proximal as possible on the ascending aorta, with attention to hemodynamic stability. The marked area of the aortic wall was excised, and the beveled base of

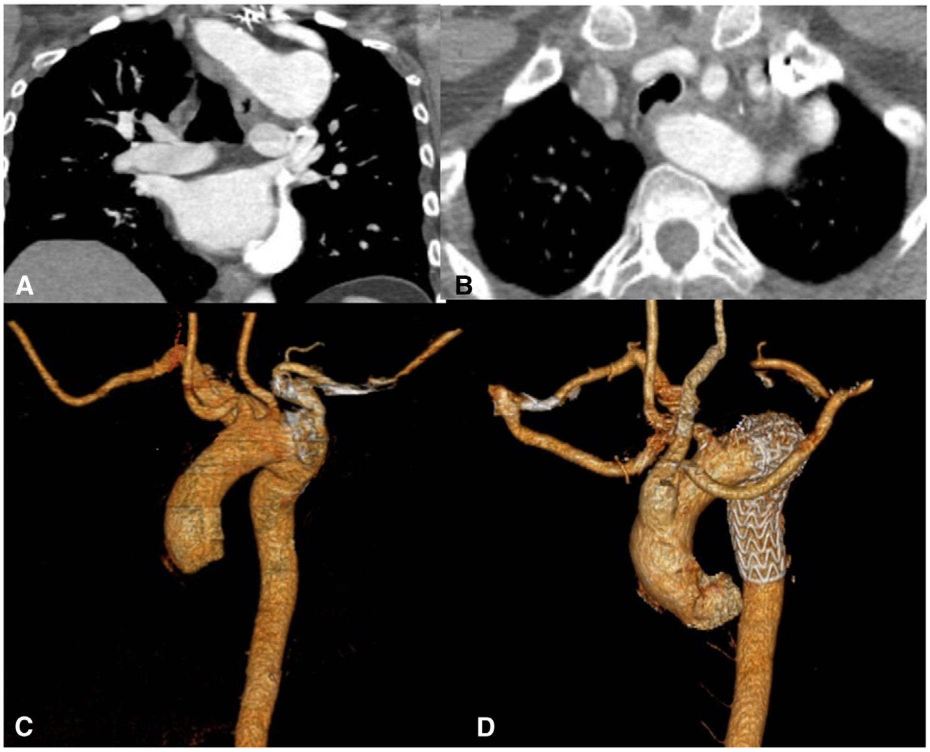

FIGURE 1. A and B, Preoperative CTA with an aneurysmal KD and aneurysmal ARSA with retroesophageal course. C, 3D reconstruction preoperatively. D, 3D reconstruction at 6 months' follow-up.

the trifurcated graft was sewn to the ascending aorta using continuous 4-0 polypropylene in the standard fashion. The clamp was removed, and the branches were deaired and individually clamped (Figure 2, *A*).

The pleura was opened bilaterally. Axillary incisions were explored and the rib spaces inferior to the axillary neurovascular bundles were identified, entered, and enlarged. A Crawford aortic clamp was used to deliver the 8-mm branches to the axillary incisions bilaterally, with care to avoid kinks or twists. Division of the internal mammary veins bilaterally allowed for a smooth lay of the grafts to bilateral axillary arteries. The 8-mm grafts were anastomosed end-to-side to the respective axillary arteries.

The left carotid incision was explored and the plane posterior to the left sternocleidomastoid was established using blunt dissection and communicated into the mediastinum. The 10-mm branch was delivered anterior to the innominate vein into the left carotid incision and anastomosed end-to-side.

A pigtail catheter was advanced from the left femoral artery into the ascending aorta, and an aortogram confirmed excellent flow and lay of all branches (Figure 2, *B*). The left common carotid artery was ligated proximal to the anastomosis.

A 22-Fr sheath was inserted in the right femoral artery (GORE DrySeal) and an endograft (31 × 31 × 150 mm, GORE TAG Conformable) was advanced to zone 1 over a stiff wire and deployed in the standard fashion. The hoods of the axillary anastomoses were used for retrograde subclavian coiling. Small 2-mm purse-strings were applied, the hoods were accessed, and 6-Fr long sheaths inserted (Destination sheath; Terumo). Subclavian angiograms were obtained and the takeoffs of the vertebral arteries were identified. Coils (Interlock-35; Boston Scientific) were deployed proximal to the vertebral arteries and a good seal was achieved. Final angiogram confirmed no endoleaks and excellent antegrade flow to all branches (Figure 2, *C*). Protamine was given, the devices were withdrawn, and closure proceeded in the standard fashion.

The patient recovered well. A follow-up computed tomography angiogram at 6 months showed all graft limbs to be widely patent and no endoleaks (Figure 1, *C*). Her preoperative chest pain resolved.

COMMENT

In the majority of instances, KD requires no intervention. When an intervention is indicated, no standardized approach is well established. Fifty-two percent of cases reported in the literature were repaired in a staged fashion

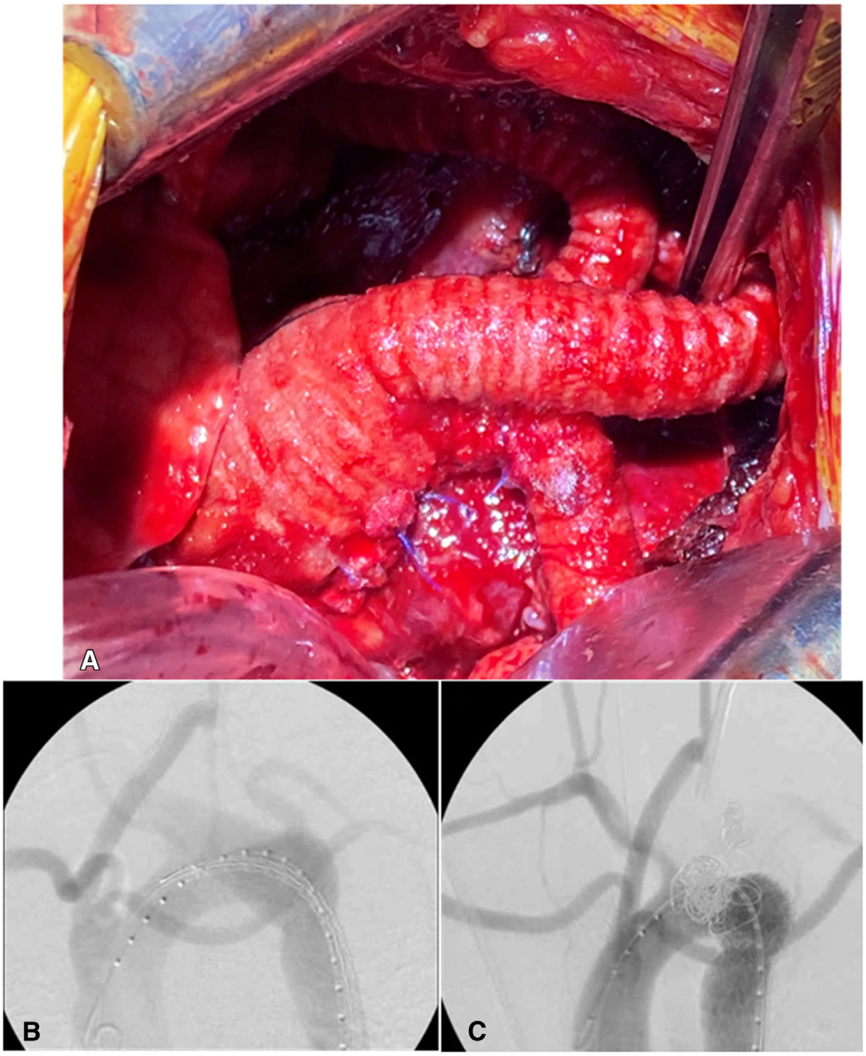

FIGURE 2. A, Trifurcated graft to the ascending aorta through an upper ministernotomy. Angiograms before (B) and after (C) TEVAR and embolization of the subclavian arteries.

(2 or 3 stages).[1] Reported endovascular repair was either purely endovascular with coverage of both subclavian arteries without revascularization at all or with various configurations of bypasses or transpositions in the neck, most commonly bilateral carotid–subclavian bypasses.[2-5]

Total arch replacement has been reported for the treatment of KD.[6,7] It is preferred when insufficient landing zone exists between the LCCA and the KD or when anatomic reconstruction is preferred. Anatomic reconstruction has the potential benefits of more physiological antegrade flow and also that the inflow of arch branches is separate and not relying on a single (usually innominate artery) or dual inflow. These benefits are likely more important in younger patients with expected longevity, but they come at the cost of a more-invasive intervention with CPB and deep hypothermic circulatory arrest. Another common approach is a right carotid to ARSA bypass followed by resection of the KD with or without reimplantation of the LSA through a left posterolateral thoracotomy.[8] This also requires left heart bypass or total CPB and deep hypothermic circulatory arrest.

Our technique maintains the benefits of a single-stage procedure that achieves multiple separate antegrade inflows to the head vessels, without the need for CPB and hypothermic circulatory arrest (Figure 3). Another advantage to this technique is the ability to implement the same technique, whether it is a left- or a right-sided aortic arch. We are not aware of another technique that provides these advantages combined. To our knowledge, this technique has not been previously described. More patients and longer

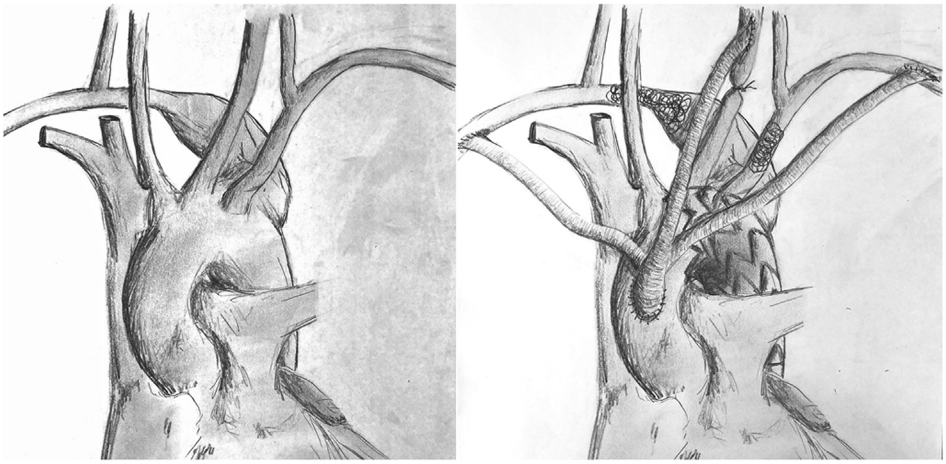

FIGURE 3. Illustration of preoperative (*left*) and postoperative (*right*) anatomy. In the *left panel*, the KD and aneurysmal ARSA arise posterior and in close vicinity to the LSA. In the *right panel*, a trifurcated graft arises from the ascending aorta supplying the left carotid and bilateral axillary arteries, which are proximally ligated or coiled respectively. A TEVAR endograft is landed in zone 1.

follow-up are needed to fully validate the performance of this technique.

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