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

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Glossary of abbreviations:

ARSA: Aberrant right subclavian artery
CPB: cardiopulmonary bypass
CTA: Computerized tomographic angiography
DHCA: Deep hypothermic circulatory arrest
KD: Kommerell diverticulum
LCCA: Left common carotid artery
LSA: Left subclavian artery
LSCM: Left sternocleidomastoid
TEVAR: Thoracic endovascular aortic repair
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.

Central image legend:
Single-stage hybrid technique for off-pump management of Kommerell’s diverticulum.

Abstract:
Management of symptomatic Kommerell’s diverticulum is not standardized. Different approaches have been described for repair. We present a technique that we believe mitigates the limitations of the reported techniques.
Kommerell’s diverticula (KD) are uncommon. When a KD is identified, repair is indicated if symptomatic, or if interval growth is demonstrated. Due to rarity, no standardized technique has been established. Approaches reported have various limitations that include multiple operative stages, need for cardiopulmonary bypass 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 presented with 2 weeks of persistent chest pain. Work up for coronary disease was negative, and a computerized tomogram (CT) of the chest revealed a posteriorly emanating 52mm KD giving rise to a 34mm 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 3mm proximal to the Kommerell’s diverticulum (figure 1A and 1B). Given the otherwise unexplained pain and the size of the aneurysms, intervention was recommended. IRB approval not required (Does not meet DHHS definition of “research”). Patient provided informed written consent.

Technique

A 2cm incision was made at the anterior border of the left sternocleidomastoid (LSCM) 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 6Fr sheaths were inserted.

An upper hemi-sternotomy was made into the right 3rd 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 10mm graft (Hemashield Gold, Getinge, Sweden) into the inflow of a bifurcated 16x8x8mm graft (Hemashield Gold, Getinge, Sweden) to create a trifurcated graft with a beveled inflow of about 20mm, and three outflows: two 8mm and one 10mm branches. 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 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 de-aired and individually clamped (figure 2A).

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 8mm 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 8mm grafts were anastomosed end-to-side to the respective axillary arteries.

The left carotid incision was explored and the plane posterior to the LSCM was established using blunt dissection and communicated into the mediastinum. The 10mm 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 2B). The left common carotid artery was ligated proximal to the anastomosis.

A 22 Fr sheath was inserted in the right femoral artery (22Fr, DrySeal, W. L. Gore, Newark DE) and an endograft (31 x 31 x 150mm, Conformable-TAG, W. L. Gore, Newark DE) 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 2mm purse-strings were applied, the hoods were accessed, and 6Fr long sheaths inserted (Destination sheath, Terumo, Tokyo, Japan). Subclavian angiograms were obtained and the takeoffs of the vertebral arteries were identified. Coils (Interlock-35, Boston Scientific, Watertown, MA) 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 2C). Protamine was given, the devices were withdrawn and closure proceeded in the standard fashion.

The patient recovered well. A follow up CTA at 6 months showed all graft limbs to be widely patent and no endoleaks (figure 1C). 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 (2 or 3 stages).\(^1\) Reported endovascular repair were 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.\textsuperscript{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 are 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 cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest (DHCA). 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.\textsuperscript{8} This also requires left heart bypass or total CPB and DHCA.

Our technique maintains the benefits of a single-stage procedure that achieves multiple separate antegrade inflows to the head vessels, without the need for cardiopulmonary bypass 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 follow up are needed to fully validate the performance of this technique.

**Figure legends**

*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.

*Figure 2:* A: Trifurcated graft to the ascending aorta through a upper mini-sternotomy. Angiograms before (B) and after (C) TEVAR and embolization of the subclavian arteries.

*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.
IRB approval not required (Does not meet DHHS definition of “research”). Patient provided informed written consent.

References
