Video Presentation

Aneurysmectomy for Crawford’s type-I thoracoabdominal aortic aneurysm using Hemashield Gold Woven Double Velour Vascular Graft and reimplantation of the visceral vessels under mild hypothermic extracorporeal circulation: a video presentation


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Introduction

Based on the expected risk of neurological deficits involving the spinal cord and the risk of renal failure and mortality, Crawford and colleagues classified thoracoabdominal aortic aneurysms into four extents [1-5]. Type-I thoracoabdominal aortic aneurysms involve the descending thoracic aorta proximal to the level of 6th rib to above the renal arteries; type-II extends from the proximal descending thoracic aorta above the level of T6 to below the renal arteries; type-III extends from below the level of T6 in the descending aorta and a variable extent in the abdominal aorta; type-IV thoracoabdominal aortic aneurysm involves the abdominal aorta without involvement of the descending aorta [1-5].

Medial degenerative aneurysms of the descending thoracic aorta or thoracoabdominal aorta are associated with loss of elastic tissues in the aortic wall. As aneurysms enlarge, there is an increasing amount of atheromatous material deposition and clot formation within the aneurysms. Due to the formation of intra-aneurysmal clots, the intercostal vessels get obstructed. In such patients, therefore, the collateral blood supply to the spinal cord becomes critical for the viability of the spinal cord. With the progression of the disease, due to extensive atherosclerosis, the visceral arteries namely, renal artery, celiac artery and superior mesenteric artery get stenosed/occluded [4,5]. These lesions often attain considerable size before they are discovered [6,7]. Since the aneurysmal pulsations are not usually palpable, a large aneurysm may go unnoticed until symptoms occur. The late presenters may present with “trash foot”, pancreatitis, abdominal angina, bowel infarction, intermittent claudication and progressive renal failure. In patients with extensive atherosclerosis/calcification, the aorta and visceral artery origins need to be endarterectomized [1-5]. In cases of long-segment stenosis, concomitant visceral bypass grafts may have to be performed. The field of endovascular stent grafting is rapidly expanding and developing and is useful in select instances of high-risk thoracoabdominal aortic aneurysms [1-5].
Concern over paraplegia has existed since the earliest days of aortic surgery with surgical treatment of coarctation of the aorta in 1945 [8,9]. Although spinal cord is protected from ischemic damage in coarctation of the aorta, the collateral circulation remains insufficient for prolonged temporary occlusion required for resection of aortic aneurysm [8,9].

Several ingenious techniques have been used clinically to prevent ischemic injury to the spinal cord. These techniques include: a) controlled extracorporeal circulation as was practised by Denton A. Cooley in 1957 [10]; b) atrio-femoral bypass with an interposed mechanical pump or with an oxygenator in the circuit [11]; c) femoro-femoral bypass with an interposed oxygenator [12]; d) a Gott’s aorto-aortic heparin-coated vascular shunt [13]; and e) a Gott’s tube between left ventricular apex and lower half of body [14,15].

Although the above techniques were beneficial in preventing paraplegia and reducing strain on the left ventricle in the hands of several investigators across the world, they have all introduced additional complications and slowly have fallen into disfavor [16-19].

The Texas Heart Institute Group advocated simple aortic cross-clamping with expeditious removal of the aneurysm without any such support measures and restoration of pulsatile flow. This group and other investigators published their clinical observations that indicate that periods of 30 minutes of aortic occlusion was well tolerated with a low incidence of paraplegia [16-19]. We do not have any experience in using this technique.

Over the years, there have been considerable improvements in the surgical results of thoracoabdominal aortic aneurysms. In a series of 832 patients, for patients operated since 1986 at the Cleveland clinic, the surgical rate was 98% with a 5% risk of paraplegia/paraparesis [20]. In an extensive review of 1509 thoracoabdominal aortic aneurysm repairs, the mortality was 8% and the risk of paraplegia/paraparesis was 16% [2]. The Crawford type-II thoracoabdominal aortic aneurysm continues to have a high risk of mortality with an increased risk of paraplegia/paraparesis [21]. The risk of developing paralysis in Crawford's type-I aneurysm varied according to whether the aortic involvement was below the celiac artery [20,21]. In the long-term follow-up in patients undergoing all types of aortic surgery, whether ascending aortic arch, descending thoracic aorta, thoracoabdominal aorta or abdominal aorta for aortic dissection, the 5-year survival has been 60% [1-5].

We present here-in a 59-year-old hyperactive hypertensive male patient presented with persistent non-radiating, non-colicky pain in the upper abdomen and back of three years duration. There was no history of trauma or chest infection. Computerized tomographic angiography revealed normal coronaries, normal-sized ascending aorta, aortic arch and proximal descending thoracic aorta. There was a large multiloculated (9x6 cm) fusiform aneurysm involving the abdominal aorta from the level of 6th rib to above the renal arteries (Crawford type-I). The celiac and superior mesenteric arteries were arising from the aneurysmal sac and renal arteries were normal. The abdominal aortic bifurcation and the common iliac arteries were normal. The results of the pulmonary function tests were within normal limits.

**Surgical techniques**

**The operation: position and surgical approach**

The operation was performed with the patient in a 45° lateral position, so that access could be made to the proximal thoracic aorta through the thoracotomy incision and also to the common femoral vessels for femoral arterio-venous cannulation.

The initial thoracic incision was made through the sixth intercostal space, continuing downward to the midline in the abdomen, and then extending through the linea alba to a point below the umbilicus. The cartilaginous costal margin was divided with bone shears. A self-retaining retractor was placed in the thoracotomy incision, and the diaphragm was opened 4 to 6 cm to facilitate exposure of the proximal abdominal aorta. The diaphragm was not incised deeply to the level of aortic hiatus to avoid the possibility of the phrenic nerve injury.

The lesion was inspected to determine the proximal and distal extent. The proximal thoracic aorta was then mobilized and looped using an umbilical tape. The lateral gutter of the peritoneum was opened down to the common iliac veins and back of the descending colon and spleen and total evisceration of the abdominal viscera including the jejunum, ileum, left kidney and spleen was done. Both common iliac arteries were dissected and looped using an umbilical tape avoiding injury to the common iliac veins.

A double-lumen endotracheal tube allowed the collapse of the left lung, thereby facilitating the operation. The right lung which is larger than the left provided adequate ventilation during intrathoracic dissection.

**Isolation of the vagus and left phrenic nerve**

The vagus nerve pedicle was dissected away from the descending thoracic aorta and looped. The left phrenic nerve pedicle was dissected and isolated using an umbilical tape.

**Exposure and cannulation of the femoral artery and femoral vein**
An infrainguinal vertical incision was made over the right femoral artery. Both the right femoral artery and right femoral vein were dissected and looped to facilitate later cannulation. Following systemic heparinization, elective femoral arterio-venous cannulation was performed using long femoral arterial and venous cannulae (Edwards Lifesciences, LLC, One Edwards Way, Irvine, CA, USA).

**Cannulation of the proximal descending thoracic aorta**
The descending thoracic aorta above the aneurysm was cannulated and connected to a bypass circuit for antegrade aortic perfusion. The femoral arterial perfusion was used for distal aortic perfusion.

**Completion of the aortic dissection under controlled extracorporeal circulation**
Under normothermic controlled extracorporeal circulation, the descending thoracic aorta above and below the aneurysm was dissected for proximal and distal aortic control. Meticulous attention was exercised not to injure the intercostal arteries during the process of dissection.

**Cross-clamping of the descending thoracic aorta above the aneurysm**
The descending thoracic aorta was cross-clamped proximally 2 cm above the aneurysm.

**Proximal graft-aortic anastomosis**
The descending thoracic aorta was incised above the aneurysm and a 14 cm segment of Hemashield Gold Woven Double Velour Vascular Graft (MedoxTM, Woven Hemashield, Meadox-Boston Scientific Corporation, Oakland, New Jersey) was used for the restoration of aortic continuity. The graft was sutured using 4-0 polypropylene sutures (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA), reinforced with Teflon pledgets as and when required. The graft was sutured using the interposition technique.

**Aneurysmectomy, removal of intra-aneurysmal clot, perfusion of the celiac, superior mesenteric and renal arteries**
The abdominal aorta was cross-clamped above the origin of the renal arteries. The thoracoabdominal aneurysm was incised longitudinally away from the origin of the visceral arteries. All intra-aneurysmal clots were evacuated and irrigated using cold saline. The celiac and superior mesenteric arteries were cannulated using a retrograde cardioplegia cannula with a self-inflatable balloon (RCO 14, Edwards Lifesciences, Irvine, CA, USA) and were perfused with blood during anastomosis of the graft to the distal abdominal aorta.

**Distal graft-aortic anastomosis**
The distal anastomosis was performed by the inclusion technique using 4-0 polypropylene suture with supports of Teflon pledgets as considered necessary.

**Reimplantation of the celiac, superior mesenteric and renal arteries**
Using a graft cautery (Acuderm, Inc., Ft Lauderdale, Florida, USA) an incision was made over the proposed site of implantation of the celiac and superior mesenteric arteries. A side-to-side anastomosis between the graft and the aortic cuff containing the visceral vessels was done using 4-0 polypropylene suture with supports of Teflon pledgets as and when considered necessary. Care was taken not to narrow the anastomotic sites. After securing hemostasis and ensuring distal aortic perfusion, the patient was separated from cardiopulmonary bypass and successfully decannulated.

**Short- and long-term results**
The postoperative recovery was uneventful. Follow-up visit at 48th month revealed the patient in New York Heart Association functional class I with good bi-ventricular function, normal renal function and no neurological deficit.

**Conclusion**
The potential benefits of this dual arterial cannulation and selective visceral perfusion are excellent operative exposure, maintenance of perfusion to all vital organs including the brain, avoidance of circulatory arrest and performance of the operative procedure under controlled conditions. Aneurysmectomy and suturing of the patch can be performed under optimal visualization achieving perfect hemostasis.

**Conflict of interest**
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