Video Presentation

Aneurysmectomy and graft interposition of the transverse aortic arch and ascending aorta using Gelatin impregnated woven vascular prosthesis (Gelweave™) under moderately hypothermic extracorporeal circulation and selective cerebral perfusion in a patient with type-I acute aortic dissection: a video presentation

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Introduction

Anatomically, the aortic arch is defined as the segment of the aorta between a line at right angle proximal to the origin of the brachiocephalic artery and extending to a line drawn at right angle distal to the origin of the left subclavian artery [1]. Surgical treatment of the lesions of the transverse aortic arch provides one of the most formidable challenges in aortic surgery [1-6]. The major concern in aortic arch surgery is the maintenance of viability of the brain during the period of interruption of cerebral blood flow. Viability of other organs namely, kidneys, liver, intestines and spinal cord are equally important. However, these organs can tolerate a temporary period of transient ischemia [1-6].

Past four decades have witnessed a variety of techniques of maintenance of cerebral integrity during periods of circulatory interruption [1-8]. Many methods of antegrade and retrograde cerebral perfusion and circulatory arrest have been tried and reported with inconsistent and unpredictable results [1-8]. Because of cerebral autoregulation, there are inherent issues of cerebrovascular spasm, under and over perfusion into an elastic or expansile cerebral vasculature, causing cerebral edema or ecchymosis. Hypothermia has been noted to aggravate the problem when mechanical means of cerebral perfusion were used [1-8]. Although deep hypothermic circulatory arrest without selective carotid arterial perfusion has been used for operations on the aortic arch by Randall Griepp and other investigators, the hazards of deep hypothermia and circulatory arrest continue [9-16].

The operative procedures for proximal transverse arch aneurysms are most commonly hemiarch repair, aortic arch replacement with re-implantation of the aortic arch vessels as a cuff or aortic arch repair with or without distal descending elephant trunk procedure with or without deep hypothermic circulatory arrest [9-16].

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This is an Open Access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (https://creativecommons.org/licenses/by-nc/4.0/).
For aneurysms involving the transverse arch proximal to ligamentum arteriosum, the best approach is through a median sternotomy. This approach permits control of the distal thoracic aorta with the performance of the distal anastomosis through the anterior approach. If the lesion involves only the proximal portion of the transverse arch, a long, oblique anastomosis is done to restore continuity to the brachiocephalic arteries and the descending thoracic aorta. If the lesion extends into the distal portion of the transverse arch, the distal anastomosis is done separately and the brachiocephalic and left common carotid arteries are implanted as a large patch into the convexity of the graft.

We used an endoaortic balloon occlusion using a No.24 Fr Foley catheter with the following objectives:

a. Maintained the perfusion of the distal organs including the head vessels retrogradely through the femoral artery;

b. Avoided application of aortic cross-clamp, thus preventing tear/transection of the fragile intimal flap;

c. Performed the distal anastomosis by an open technique under direct vision with proper spacing of sutures, achieving perfect hemostasis;

d. Performed the procedure under moderate hypothermia, thereby avoided the complications secondary to deep hypothermic circulatory arrest; and

e. Incorporated the ostium of the brachiocephalic and left common carotid artery within the newly created neoaortic arch.

We present here-in a 58-year-old hypertensive male patient presented with acute onset precordial pain of eight hours duration. There was no history of chest trauma or chest infection. He underwent stenting of the left anterior descending and mid-right coronary artery in January 2019 for significant atherosclerotic coronary artery occlusion. The left ventricular ejection fraction was 0.50. There was no segmental wall motion abnormality. A computerized tomographic scan of the brain did not reveal any evidence of infarcts or brain lesions.

Computerized tomographic angiography revealed normal coronaries and normal aortic valve leaflets without aortic regurgitation. Angiographically, he had type-I aortic dissection with an entry point at proximal transverse aortic arch and multiple re-entry tears in the descending thoracic aorta. The false lumen was extending proximally till above the sinutubular junction and distally before the aortic-iliac bifurcation. All arch vessels were arising from the true lumen. The maximum dimension of the transverse aortic arch was 7.3 cm and the infrarenal abdominal aorta was 2.7 cm (true lumen=2 cm). He was diagnosed to be suffering from acute type-I aortic dissection with an entry point at the transverse aortic arch.

The operation was performed using femoral arteriovenous and superior vena caval cannulation, selective brachiocephalic and retrograde coronary sinus perfusion under moderately hypothermic cardiopulmonary bypass and cardioplegic arrest. While performing resection and reconstruction of the aortic arch, we used selective carotid arterial and retrograde coronary sinus perfusion for the brain and myocardium respectively.

**Surgical techniques**

**Insertion of a transesophageal echocardiographic probe**

After general anesthesia, a transesophageal echocardiographic probe was inserted to assess the dissected aorta, flow patterns in both the true and false lumens both during and after cardiopulmonary bypass, aortic valve competency and left ventricular size and systolic function.

**Exposure and cannulation of the femoral artery and femoral vein**

An infraperiinguinal 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. Elective femoral arteriovenous cannulation was performed using long femoral arterial and venous cannulae (Edwards Lifesciences, LLC, One Edwards Way, Irvine, CA, USA) following systemic heparinization.

**Position and surgical approach**

The chest was entered through a median sternotomy. The thymus was subtotally excised taking care not to injure the stretched, compressed brachiocephalic vein. A rectangular segment of the pericardium was harvested for later use, if needed. It was opened using scissors and not cautery to avoid inadvertent cautery-induced ventricular fibrillation.

**Cannulation of the superior vena cava and venting of the main pulmonary artery**

Under cardiopulmonary bypass on a partially decompressed heart, the superior vena cava was cannulated using a No.22 angled metal-tipped venous cannula. The main pulmonary artery was vented using an 18-Fr vent catheter to prevent cardiac distension.

**Dissection and isolation of the brachiocephalic vein, brachiocephalic artery and left common carotid artery**

The brachiocephalic artery, left common carotid artery and brachiocephalic vein were dissected and looped using umbilical tapes.
Insertion of a left ventricular vent through the right superior pulmonary vein
The right superior pulmonary vein was vented using a 14-Fr sump suction vent prior to aortic cross-clamp on a partially filled heart without ventilation to prevent the entry of air inside the left heart.

Cannulation of the coronary sinus using a retrograde cardioplegia catheter
A purse-string suture was placed at the medial aspect of the inferior caval vein-right atrial junction using 5-0 polypropylene (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA) suture. A retrograde cardioplegia cannula (Medtronic Inc., Minneapolis, MN, USA) was inserted through the right atrial purse-string palpating and guiding it externally with the index finger of the left hand. Special precautions were taken not to damage the wall of the coronary sinus and its tributaries. Additional transesophageal echocardiographic guidance was taken to ensure that the tip of the coronary sinus cannula lied at the base of the left atrial appendage.

Cannulation of the right brachiocephalic artery
The right brachiocephalic artery was cannulated using a No.12-Fr DLP straight cannula for selective carotid perfusion (Medtronic Inc., Minneapolis, MN, USA). Following cannulation, the perfusion line pressure was checked ensuring its intraluminal position. Throughout the operation, the brain was selectively perfused at 700-800 mL/min using a dedicated roller pump and cerebral monitoring. The head was protected using an ice pack.

Cross-clamping of the ascending aorta below the brachiocephalic artery and administration of selective ostial cold blood cardioplegia
The mid ascending aorta was opened. The true lumen was identified and incised. Myocardial protection was achieved using combined selective ostial and retrograde cold St. Thomas based (1:4) blood cardioplegia and topical cooling with ice-cold saline. Throughout the operation, myocardial protection was achieved by intermittent antegrade and continuous low potassium retrograde cardioplegia administration.

Removal of the thrombus within the dissected aortic flap
The clotted blood lying in between the true and false aortic lumen was removed. The lumen was irrigated using cold normal saline.

Preparation of the cardiac end of the ascending aorta
Three Teflon strips were placed intraluminally within the aorta, in between the true and false lumen and outside the aortic wall. A series of interrupted 4-0 polypropylene (Johnson and Johnson Ltd., Ethicon, LLC, San Lorenzo, USA) sutures were used to appose the true and false lumen. 5 mL Bioglue (M/s Crolife Inc, Kennesaw, Georgia, USA) was injected within the dissected flap for firm apposition of the dissected flap. This step is extremely important to prevent sutures cutting through and to ensure perfect hemostasis.

The anastomosis of the graft to the proximal end of ascending aorta
A graft sizer was used for the measurement of the transected end of the ascending aorta. A 32 mm Gelatin impregnated woven vascular prosthesis (Gelweave™, Vascutek Ltd, a Terumo Company, Newmain’s Avenue, Renfrewshire, Scotland, UK) was anastomosed to the proximal transected end of the ascending aorta using multiple horizontal mattress and over and over continuous sutures of Teflon felt supported 3-0 polypropylene suture.

Administration of root cardioplegia
After completing the proximal graft-aortic anastomosis, a No.18 Fr Foley catheter was inserted within the graft and root cardioplegia was administered. In addition to myocardial preservation, this technique allowed us to check for hemostasis of the graft-aortic suture line.

Restoration of myocardial perfusion and endoaortic occlusion of the aortic arch through the aneurysm sac using a No.24 Fr Foley catheter
The patient was placed in the Trendelenburg position. The right brachiocephalic artery was snugged and the perfusion flow rate was temporarily lowered to 1.5 L/min. The aneurysm was incised at its center and the contained intra-aneurysmal clots were evacuated. A No.24 Fr Foley catheter was advanced through the opened aneurysmal sac into the aortic arch, the balloon was inflated and the whole
Reconstruction of the transverse aortic arch

The healthy margins of the arch aneurysm were identified after excising the tear within the transverse aortic arch. The distal end of the graft was spatulated and an appropriate length of the prosthetic graft was retained. The proximal arch was reconstructed using the distal end of the graft by interposition technique. The graft aortic anastomosis was performed in two layers: interrupted 3-0 pledgeted mattress and over and over felt supported continuous suture of 3-0 polypropylene ensuring perfect hemostasis. The endoaortic Foley’s catheter was deflated and withdrawn.

Care was taken not to narrow the origin of the brachiocephalic artery and retrograde low aortic flow to avoid air embolism. After securing hemostasis and ensuring myocardial and distal aortic perfusion, the patient was fully rewarmed and was decannulated.

Short- and long-term results

Postoperatively, transesophageal echocardiography demonstrated normal ventricular function (left ventricular ejection fraction 0.5) on dopamine 5 µg/kg/min, dobutamine 10 µg/kg/min and sodium nitroglycerine 0.5 µg/kg/min. The postoperative recovery was uneventful. At 24 months of follow-up, the patient was in New York Heart Association functional class I with normal biventricular function and no neurological deficit.

Conclusion

The potential benefits of this endoaortic occlusion technique are excellent operative exposure, maintenance of perfusion of all the vital organs including the brain, avoidance of complications secondary to deep hypothermia and circulatory arrest and performance of the operative procedure under controlled conditions. Aneurysmectomy and sutureing of the graft can be performed under optimal visualization achieving perfect hemostasis. Selective carotid arterial perfusion under controlled conditions and neurologic monitoring effectively prevents any neurologic injury. Concomitant retrograde myocardial perfusion reduces myocardial anoxic time in these situations of prolonged surgical procedures.

Conflict of interest

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