Repair of Aortic Arch Aneurysm Under Cardiopulmonary Bypass And Deep Hypothermia With Low Flow: A Case Report

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Abstract:

Aortic arch surgery is the challenging and most difficult surgery among the cardiovascular operations. Cerebral and spinal complications are the most feared and common complications of aortic arch surgery. With best available techniques for cerebral and spinal protection, anesthetic management and good post-operative care; aortic arch surgery is considerably safer nowadays and satisfactory results can be achieved in most patients. Also, selecting the sites for arterial cannulation to maintain whole body circulation, during isolation of the aortic arch to operate on it, need proper anatomical description of the extent of the aneurysm. This is also achievable by the availability of the imaging techniques like Computed Tomography (CT) with or without contrast, CT Angiography (CTA) and Magnetic Resonance Imaging (MRI). We are reporting a case of aneurysm of aortic arch in a young adult, who had undergone repair under cardiopulmonary bypass and deep hypothermia with low flow and had normal convalescence without any cerebral or spinal complications.

Key words : Aortic arch aneurysm, Cerebral protection, Deep hypothermic circulatory arrest, Retrograde brain perfusion, Antegrade brain perfusion.

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Introduction:

Cerebral protection during aortic arch surgery is vital for neurological outcome in postoperative period. The optimal selection of cerebral protection strategies is vital in aortic arch surgery. A fundamental component of cerebral protection has been Deep Hypothermic Circulatory Arrest (DHCA), which is supplemented by Retrograde Cerebral Perfusion (RCP) or Antegrade Cerebral Perfusion (ACP) for the optimal cerebral protection. The availability of the sophisticated imaging technique helped to plan the complex surgery of aorta preoperatively. This helps for proper selection of the operative procedure and also selection of sites for the cannulation of greater arteries for the cerebral perfusion. In this report, we are going to evaluate a case who underwent aortic arch repair under hypothermia with low flow and antegrade cerebral perfusion. Fig-2 :

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Case report:

Md. Nizam, a 35 year normotensive and non-diabetic gentleman hailing from Patuakhali was admitted in our department with the complaints of chest pain since 3 months and change in voice since 2 and half months. According to him, he was apparently well 3 months back. Then he started having central and right-sided chest pain which was gradual on onset, dull aching and non-radiating. The pain was not related with exertion, breathing and continuous on nature which got relieved after taking analgesics. On query, he had left upper limb pain 3 months back for 1 month, which got relieved spontaneously. He was an ex-smoker who smoked 2 pack-year. He quitted smoking 3 months back after he started having this problem. He came from a low socio-economic family.

On examination, pulse was 78 bpm, regular, normovolemic, normal in character, condition of vessel wall was normal and all peripheral pulses were palpable except pulse of left upper limb. Left brachial, radial and ulnar pulses were not palpable. Other general examination findings were within normal limits. All systemic examination findings revealed normal findings.

His routine investigations were within normal limits. Chest X-ray showed well circumscribed dense homogenous opacity occupying the left upper zone with medial border merged with mediastinal shadow, trachea shifted to right (Fig. I). Multiaxial contrast and no-contrast CT scan of the chest showed a fusiform dilatation at arch of aorta measuring about 10.1 cm in craniocaudal, 7.7 cm in anteroposterior and 6.8 cm in transverse diameter. On post contrast scan, strong homogenous enhancement of the lumen with eccentric non-enhancing hypodense area represents thrombus suggestive of aortic arch aneurysm with mural thrombus (Fig. II). Fibre-optic laryngoscopy showed left-sided vocal cord paralysis. CT angiogram showed large saccular aneurysm measuring about 6.9 cm X 8 cm having mural thrombus was seen involving origin and proximal part of left subcalvian artery. The mural thrombus measured about 2 cm with internal patent lumen of about 6.5 cm X 5.9 cm. The lesion had mildly compressed the adjacent aortic arch and left common carotid artery. Neck of aneurysm measured about 16.4 mm, saccular aneurysm measuring 20 X 18 mm was seen in proximal right subclavian artery (Fig. III).

With all these clinical and investigation findings, patient underwent repair of aortic arch aneurysm under cardiopulmonary bypass and deep hypothermia with low flow. Operation procedure was performed as follows: Median sternotomy was done, which was extended perpendicularly along the left 2^{nd} intercostal space upto the mid-clavicular line. Huge aneurysm was seen just distal to the origin of brachiocephalic trunk with massive adhesion around the aneurysm (Fig. IV). Cardiopulmonary bypass was established with 22 Fr aortic and right femoral cannula and two-stage 36 Fr venous cannula. After applying cross-clamp over ascending aorta, it was found that cerebral perfusion could not be secured if aneurysm is opened up. So, it was decided to selectively cannulate brachiocephalic trunk and control was taken just at the origin of brachiocephalic trunk. Deep hypothermia with low flow was attained below 20^0C and cross-clamp was applied on descending thoracic aorta to isolate the aortic arch from the cardiopulmonary bypass. The cerebral perfusion was maintained via arterial cannula at brachiocephalic trunk, and perfusion to trunk and lower limbs via femoral cannula. Antegrade cardioplegia was delivered via aortic root cannula and aneurysm was incised. Organized thrombus was seen inside the aneurismal sac, which was removed and aneurysm was found to be of saccular variety. So, replacement of aortic arch (as planned earlier) was withheld and planned for repair of aneursym. The opening of aneurysm was sutured in two layers and reinforced with pericardial patch by 4-0 prolene and wrapping of redundant aneurismal sac was done above the repaired aorta. Patient was gradually warmed upto 37^0C and weaned from cardiopulmonary bypass without difficulty. Proper hemostasis was secured. Three drains were kept, sternum was closed with sternal wire and chest was closed in layers. Total cardiopulmonary bypass time was 210 minutes with cross-clamp time of 101 minutes.

Patient was extubated 19 hours after the surgery. Apart from drain of 1050 ml on 1^{st} POD, patient was haemodynamically stable. Inotropic support was gradually tapered and stopped on 4^{th} POD and all drains were removed on 5^{th} POD. Patient was shifted to general ward on 8th POD and got discharged on 13^{th} POD. At the time of discharge, patient was haemodynamically stable and wound was in healthy condition. Patient was asked for follow-up after 1 month.

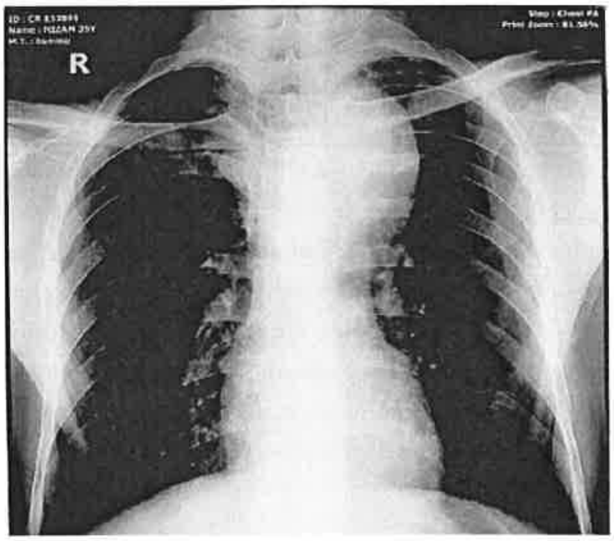

Fig-1 : *Chest X-ray showing well circumscribed dense homogenous opacity occupying the left upper zone with medial border merged with mediastinal shadow, trachea shifted to the right.*

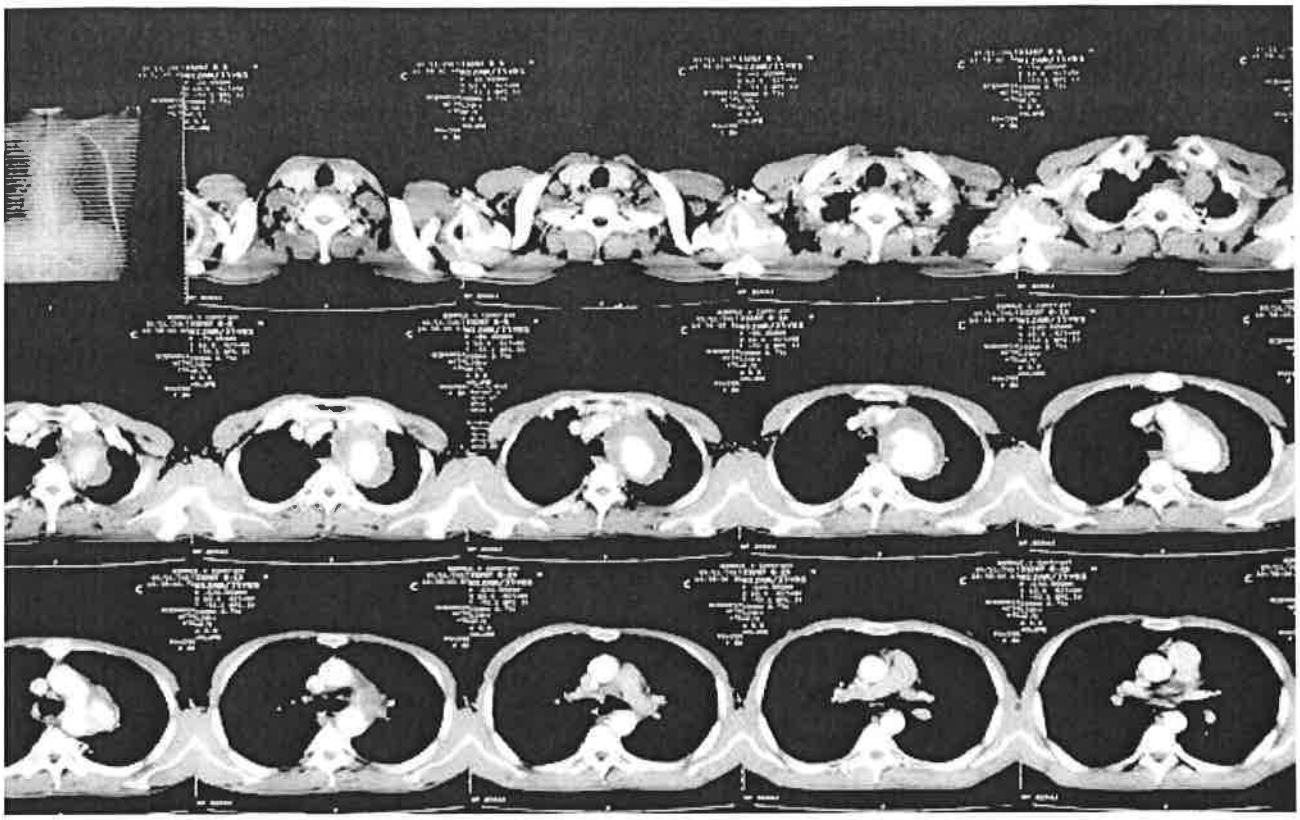

Fig-2 : *Multiaxial contrast CT scan of the chest showing strong homogenous enhancement of the lumen with eccentric non-enhancing hypodense area represents thrombus suggestive of aortic arch aneurysm with mural thrombus.*

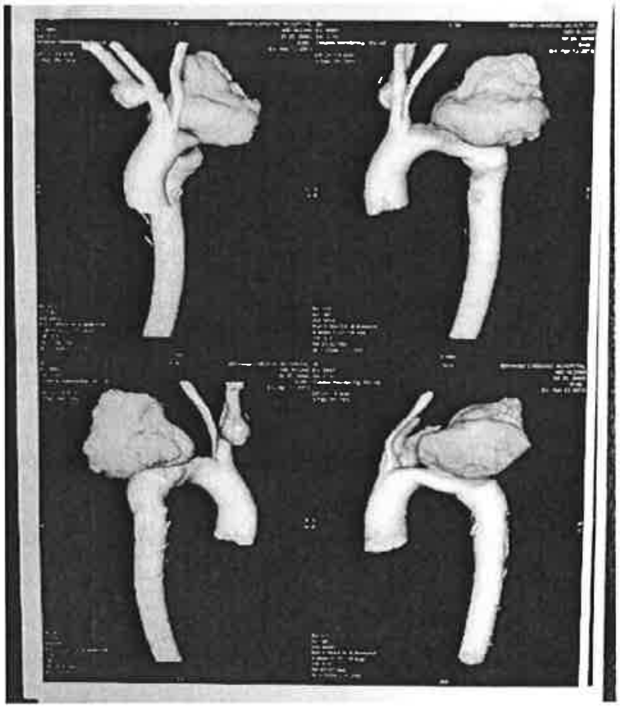

Fig-3 : *CT angiogram showing large saccular aortic arch aneurysm distal to the origin of left common carotid artery, which has mildly compressed the adjacent aortic arch and left common carotid artery. Also saccular aneurysm is seen in proximal right subclavian artery.*

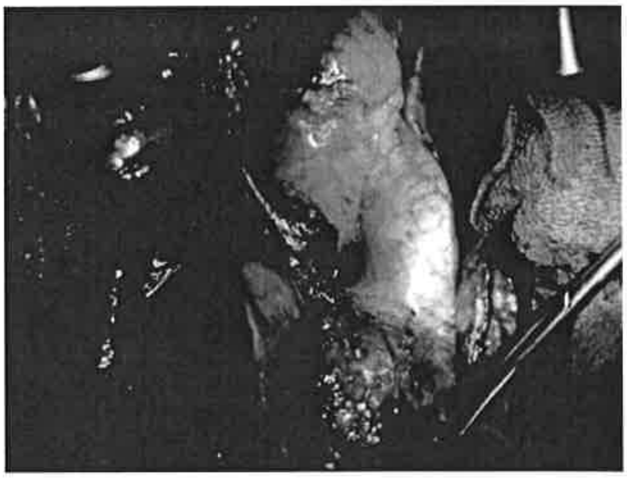

Fig-4 : *Intraoperative finding showing huge aneurysm just distal to the origin of brachiocephalic trunk with massive adhesion around the aneurysm.*

Discussion:

Anatomically, the aortic arch is defined as the segment of aorta between a line at a right angle proximal to the innominate artery origin and extending to a line drawn at a right angle distal to the origin of the left subclavian artery.[1] An aneurysm is a pathological, permanent, segmental dilatation of an artery to more than 1.5 times its normal diameter.[1,2] Aneurysm have clinical implications because of their ability to rupture, leak or embolise.[2] Aneurysms can be classified into aortic aneurysms without penetration through the aortic adventitia (true aneurysms) and those that penetrate through the adventitia and are contained by the surrounding tissue, which prevents exsanguinations of the patient (false aneurysms). In addition, aneurysms are classified according to their likely etiology: medial degenerative aneurysms; related to aortic dissection, connective tissue disorder, trauma, primary aortic infections or after previous cardiovascular surgery, aortitis and congenital anomalies. Aneurysms can be either fusiform, showing uniform dilatation, or saccular in appearance.[1] The three most common sites for saccular aneurysms are on the lesser curve of the aortic arch, on the descending thoracic aorta, and opposite the visceral vessels.[3] Although our patient had saccular variety of aortic arch aneurysm, it was present on the greater curve of the aortic arch, uncommon site for it.

Aortic aneurysms are the 13th-leading cause of mortality in United States and the incidence of thoracic aortic aneurysms is increasing with improvements in screening, as well as advances in imaging.[4] Multidetector Computed Tomography Angiography (CTA) allows the comprehensive evaluation of thoracic aortic aneurysms in terms of morphologic features and extent, presence of thrombus, relationship to adjacent structures and branches, and signs of impending or acute rupture.[5] Also it helps in the planning for the site for cannulation during establishment of cardiopulmonary bypass. CT scan with contrast and non-contrast and CTA were done for the comprehensive evaluation of aneurysm in our patient. CTA findings showed the aneurysmal dilatation was present distal to the origin of the brachiocephalic trunk, and was planned preoperatively to cannulate the ascending aorta and applying the cross-clamp at the arch distal to the origin of brachiocephalic trunk maintaining the cerebral perfusion via the brachiocephalic trunk. However, due to the presence of the massive adhesion of the aneurysmal sac close to the brachiocephalic trunk, cross-clamp could not be applied in the aortic arch and so selective cannulation of brachiocephalic trunk was done in our case. Hence it was found that only the preoperative imaging is not the reliable for planning the technique, instead it should be judged with intraoperative findings in addition with the preoperative imaging.

Before the advent of cardiopulmonary bypass machines, bypass shunting from the ascending aorta to the great vessels were designed for cerebral and whole body perfusion. However, this technique was limited in patients with normal aortic root and who had no extensive aneurysms. Also, it was associated with a high incidence of stroke and death. After the advent of cardiopulmonary bypass, the operations of aortic arch became considerably safer but it was found that, directly cannulating aortic arch greater vessels for perfusion of the brain were associated with a high incidence of stroke – occurring in up to one-third of the patients. Their view was that this was related to injury of the greater vessels by balloon catheters and occluding clamps or atheroma resulting in stroke.

Bernard, Schrire and Borst with their colleagues independently pioneered deep hypothermia for aortic arch surgery and was later popularized by Griepp.[1] Deep hypothermic circulatory arrest (DHCA) is used as the primary neuroprotection mechanism since the 70s. Although the brain accounts for only approximately 2% of the body weight, it utilizes 20% of the resting total body oxygen consumption and receives almost 15 – 20% of the total cardiac output. Hypothermia inhibits injury-induced pathways by significantly decreasing the global cerebral metabolic rate for glucose and oxygen.[7] In fact, for every 1°C drop in body temperature, cellular metabolism slows down by an average of 5–7 %.[7] However, increase in DHCA duration has been associated with poorer neurological outcomes. Nevertheless, the convenience, simplicity and effectiveness of DHCA justify the use of DHCA till date.[8] Although DHCA is not used in our patient, the core temperature was reduced to below 20^{0}C, reducing the metabolic demand of the whole body, especially of the brain. Thus, it helps in cerebral and spinal protection during repair of the aortic arch.

After the advent of CPB, perfusion of brain for cerebral protection using the retrograde arterial flow via the superior venacava was successfully used by Lemole and colleagues in early 80_s.[9] Mills and Ochsner are credited for the original use of retrograde cerebral perfusion (RCP) to treat accidental air embolism that occurred from arterial inflow cannula during the CPB in 1980.[1,9] The beneficial effects of RCP may be ability to sustain brain hypothermia during DHCA and removal of embolic material from the arterial circulation of the brain.[9] Although RCP has these beneficial effects, it is not a completely safe technique for cerebral protection and is associated with harmful side effects, including stroke or neurocognitive deficits and depression. This may be associated with brain edema due to higher perfusion pressure needed to obtain any retrograde perfusion of the brain. The perfusion pressure exceeding 60 cm H_2O is found to be associated with development of brain edema.[1] Antegrade cerebral perfusion showed more physiological similarities of cerebral blood flow and is associated with less side-effects in comparision to the retrograde cerebral perfusion.

Finally, the superiority of one approach over another will be very difficult to determine without multicenter randomized controlled trials. In institution like ours, where surgery of aortic arch is performed once in a blue moon, the acquaintance of the experience and determination of perfect technique after this first successful surgery is a just a beginning and there is long gap between our knowledge and the experience. Use of DHCA is the fundamental technique for the cerebral protection. In addition to DHCA, antegrade or retrograde cerebral perfusion will be beneficial. Our success in this patient may be due to use of best available techniques, viz. deep hypothermia with low flow and antegrade cerebral perfusion. We hope for more experience in the field of aortic arch repair and more perfection in the techniques in near future.

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