Case Report

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Total Aortic Arch Replacement: Case Report of the first successful total arch replacement in Nepal and Review of contemporary techniques in arch surgery

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Abstract

Aortic arch replacement is formidable cardiac surgery that is fraught with complications like brain injury, coagulopathy along with high mortality. Over the past several years, various techniques like deep hypothermic circulatory arrest, retrograde cerebral perfusion, and selective antegrade cerebral perfusion along with branched graft techniques have been developed with better early outcomes. We share our experience of successful replacement of ascending and total aortic arch in a 60 years old female, who presented with ascending and aortic arch aneurysm.

Keywords: Deep hypothermic circulatory arrest, Retrograde cerebral perfusion, Selective antegrade cerebral perfusion, Branched aortic graft, Total aortic arch replacement

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Introduction

Aortic arch replacement is one of the most challenging operations in cardiovascular surgery. Surgery involves interrupting blood supply to brain, which is the most oxygen dependent organ in the body. Traditionally, surgery has been carried out, by subjecting profound hypothermia (18-20°C), to reduce metabolic demands, along with surgical haste to minimize cerebral ischemia time. Later on techniques of cerebral perfusion (antegrade or retrograde) has been added to increase the safety of the procedure. Graft modifications include using branched graft instead of single tubular graft for technical simplicity and dissociation of brain and rest of the body regarding circulation.

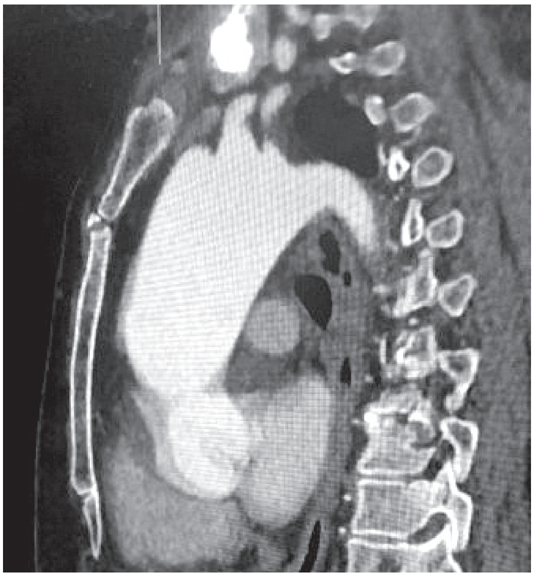

Figure 1: CT Angiogram

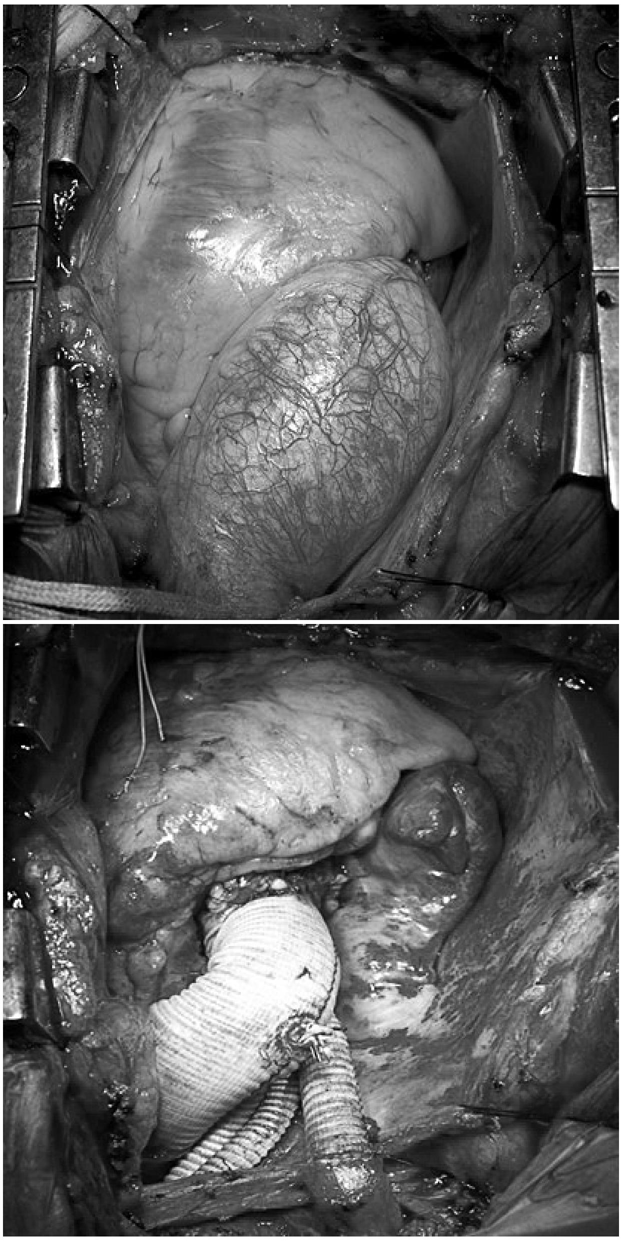

Figure 2: Intraoperative Images

Case Report

Sixty years old female diagnosed with bicuspid aortic valve, ascending and arch aneurysm presented with palpitation for 5 months along with lower limb swelling for 2 years prior to admission. Echocardiogram showed bicuspid aortic valve, with mild aortic stenosis (peak gradient: 25mmHg; mean gradient: 13mmHg), mild aortic regurgitation. Left ventricular dimensions in diastole was 5.4 cm and in systole was 3.4 cm. Her ejection fraction was 55%. CT scan showed ascending aorta (max. dimension) as 6.7x6.1 cm, sinotubular junction 3.7 cm, mid aortic arch 5.7 cm. (Figure 1). Patient was taken for surgery on 29/ 9/2075 B.S (January 13, 2019 AD). The intraoperative images are shown below. (Figure 2)

Right femoral artery and bicaval cannulation was done. Patient was cooled down to 25°C. Dacron graft (8mm) was sutured to innominate artery and blood was pumped through separate roller pump into the innominate artery. Innominate artery was divided proximal to the graft, arch end was sutured; left carotid artery was divided and separate cannula was used for selective antegrade cerebral perfusion into the left common carotid artery. Meanwhile heart started to fibrillate due to hypothermia, so cross clamp was applied and antegrade cardioplegia given. Aortotomy was done and osteal cardioplegia was given.

Left subclavian artery was then divided. Proximal descending aorta clamped and femoral perfusion continued along with selective antegrade cerebral perfusion (SACP) throughout the procedure. Ascending aorta from sinotubular junction to aortic arch, just distal to the origin of left subclavian artery was excised. Dacron graft (24mm), with 4 branches, was anastomosed distally to descending aorta and proximally to sinotubular junction. After proper de-airing, cross clamp was removed. Fourth branch of the graft was used for lower body perfusion, stopping femoral perfusion. Left common carotid artery and innominate artery were anastomosed to graft, providing flow to the brain through the main graft. Subclavian artery was finally anastomosed to graft branch.

Total cardiopulmonary bypass time was 243 minutes and aortic cross clamp time was 133 minutes and antegrade cerebral perfusion time was 138 minutes. Chest wall closed primarily.

Post operatively patient required very minimal amount of inotropic support and was extubated next morning. She was discharged home on 7th post-operative day. She has been on regular follow up and her status has been unremarkable.

Discussion

Aortic arch surgery has been associated with high rates of morbidity and mortality. Traditional surgery involves interrupting cerebral blood flow, necessitating the use of strategies to protect brain in the process. Deep hypothermic circulatory arrest (HCA) was developed as an adjunct for aortic arch surgery in 1975 by Griepp et al.[1]. A primary disadvantage of using deep hypothermic circulatory arrest is the prolonged bypass times required for cooling and rewarming which adds significantly to the morbidity associated with these procedures, especially coagulopathy-related bleeding[2,3], organ dysfunction like stroke and death[4-6]. Therefore, HCA is normally performed with the use of retrograde cerebral perfusion (RCP) or selective antegrade cerebral perfusion (SACP).

Ueda first reported using retrograde cerebral perfusion (RCP) in conjunction with deep hypothermic circulatory arrest (HCA) during ascending and transverse arch repairs[7,8]. This has been widely adopted for prevention of cerebral ischemia during the operative treatment of aortic arch aneurysm along with profound hypothermic circulatory arrest by various groups[9-11]. In most centers, flow is adjusted to maintain pressure in the range of 15 to 25 mm Hg with monitoring via either catheter in superior vena cava or a jugular bulb catheter[12].

Bachet et al described the technique of SACP with cold blood during surgery of the aortic arch in 1986[13]. It avoids the use of deep hypothermia, prolonged cardiopulmonary bypass with no time bound to perform the aortic repair. SACP is initiated with flow of 10ml/kg/min after occluding innominate artery[13]. As most patients have complete 'circle of Willis', right-sided SACP generally provide adequate left sided cerebral protection. When direct left-sided SACP is indicated, it can be delivered through the left common carotid artery by inserting a balloon-tipped catheter that has been connected to a Y-limb from the arterial CPB line. Tanaka et al described SACP with three-vessel cannulation using bilateral axillary cannulation with temperature maintained below 25°C[14]. With continuous SACP, surgery can be done at much warmer temperature as opposed to 18°C. Warmer temperature can reduce coagulopathy; can result in shorter bypass time, shorter length of hospital stay and lower early mortality; prevent development of lung injury and other transfusion related sequelae[15]. The optimal temperature in the setting of antegrade SACP seems to be between 20°C and 28°C[13,16,17]. Quan Li et al published their case report on 4 patients with type A aortic dissection, on whom they replaced total aortic arch, along with frozen elephant trunk of proximal descending thoracic aorta with the help of 4-branched graft at a core temperature of 34°C[18].

In an experimental study by Sakurada et al, cerebral protection efficacy of HCA, RCP, and SACP were compared and found that SACP was the safest method for arch reconstruction that requires a cerebral protection period of 90 minutes[19]. Kazui et al found SACP to be physiologically superior to HCA and RCP because it supplies sufficient oxygenated blood to the brain in an antegrade direction and therefore can be used to protect the brain for an unlimited time[20].

Hazim Saafi et al reported using RCP in 907 (82%) among 1107 cases of ascending and transverse aortic arch replacement[21]. They reported stroke rate of 2.8%, which compared favorably with other contemporary series reporting stroke incidences from 3% to 12% regardless of technique of cerebral perfusion[7,22,23]. Although Hazim Saafi et al acknowledged that adequate nutritive flow might not be provided by RCP, they concluded that the use of RCP with profound hypothermic circulatory arrest is associated with a reduction in mortality and stroke. Other reported benefits include flushing of atheromatous debris and uniform cerebral cooling[10,24,25.]

Dealing with brachiocephalic vessels

Traditionally, cuff of aortic tissue containing brachiocephalic vessels “island technique” was used to sew these vessels to the graft. It has disadvantage of improper hemostasis, especially on the posterior side. The aortic tissue left behind is often affected by atherosclerosis and might become aneurysmal later on, especially among patients with connective tissue disorder[26].

Branched graft technique developed by Spielvogel and colleagues simplifies the management of brachiocephalic vessels and provide safe access for providing continuous SACP[27]. Without interrupting blood supply to brain or with brief interruption, surgeon can anastomose all three brachiocephalic vessels to graft branches with easier access to suture line in case of bleeding. Further advantages includes shorter total pump and SACP times than those necessary in en bloc repair[28]; atherosclerotic lesions that frequently develop near the origin of arch vessels can be completely resected; anastomosis of arch vessels in area not affected by dissection[20].

Neurologic outcome

Neurologic deficit can be temporary neurologic deficit or stroke. A prospective comparative study by Okita et al[29] confirmed that SACP significantly reduced the prevalence of temporary neurologic dysfunction compared with retrograde cerebral perfusion. The incidence of stroke in studies that used HCA ranged from 0 to 11%[1,6,30], RCP 0 to about 12.5%[7,9-11] and SCP 0 to about 5.4%[20,31-34].

Preoperative factors such as pre-operative stroke and presence of occlusive arterial disease can influence the incidence of postoperative stroke34. Svensson and colleagues also reported a high incidence of stroke after operation under HCA in patients with a history of cerebrovascular disease. Therefore, in patients with old cerebral infarcts, further improvement in brain protection methods will be necessary[6].

Neurological monitoring

Conventional intraoperative monitoring for example electrocardiography (ECG), pulse oximetry, end tidal carbon dioxide and non-invasive blood pressure, gives little indication of the adequacy of oxygen delivery (DO2) to the patient during surgery.

Near-infrared spectroscopy (NIRS) is a continuous, real-time, non-invasive cerebral oximetry that allows detection of brain ischaemia. It provides regional cortical saturation (rSO2), a reflection of the balance between oxygen delivery and utilization in a given region and has been shown to correlate well with jugular venous bulb saturation and brain tissue oxygen pressure[36]. Clinical studies suggest that it is reliable in detecting perioperative cerebral oxygen desaturation events, especially in cardiac surgery, although clinical benefits remain to be proven[37].

Mortality Rates

Historically, aortic arch surgery has been associated with high mortality. Studies show mortality between 10 to 15% in studies using HCA6,30, and 6.7% in study using HCA or RCP9, 17.7% with SACP and branched graft[20]. However, contemporary studies of Aortic arch surgery with SACP reports early mortality rate from 3.4% to 8.2%[38-40].

Conclusion

Hypothermic circulatory arrest along with retrograde and selective antegrade cerebral perfusion provides effective form of cerebral protection. Along with cerebral circulatory adjunct, branched graft technique simplifies aortic arch replacement while removing the need for deep hypothermia, circulatory arrest, extended periods of cardiopulmonary bypass and time pressure on the surgeon.

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