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Repair of Coarctation of Aorta in Adults

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Abstract
The congenital cardiovascular condition Coarctation of the Aorta (CoA) causes aortic narrowing that results in hypertension and heart failure and stroke development when medical treatment is not provided. A 45-year-old male received a childhood diagnosis of CoA before his development of progressive hypertension and chest pain and differential limb blood pressure. Advanced cardiac MRI and CT angiography imaging showed the patient had severe aortic constriction. Surgical treatment for the patient included cardiopulmonary bypass during which the surgeons removed the narrowed section and inserted a graft. Postoperative imaging results showed that the aortic channel remained open with sufficient blood circulation. Adult CoA patients benefit most from surgical intervention which shows excellent outcomes when combined with prompt diagnosis. Proceeding surveillance with modern imaging techniques must be supported by team-based medical treatment to prevent complications' long-term effects. Patients must receive lifelong monitoring because it guarantees both cardiovascular wellness and best possible health results.

Keywords: Congenital heart disease. Aortic coarctation. Bicuspid aortic valve. Cardiac surgery. Aneurysm. Aorta. Treatment outcome

1. Introduction

Coarctation of the Aorta (CoA) represents a birth defect that causes aortic narrowing which blocks regular blood circulation between the heart and the body. The narrowing of the aorta takes place near the ligamentum arteriosum at the location below the left subclavian artery. Research from the mid-2010s showed that CoA appeared in 1 out of 2500 to 1 out of 2900 newborns. The worldwide annual birth numbers of 150 million result in 51,000 to 60,000 babies developing aortic coarctation (Brown et al., 2013; Van Der Linde et al., 2011). The infant requires early diagnosis and treatment of CoA to achieve complete motor-physiological development. The natural lifespan of untreated aortic coarctation patients reaches 35 years but their mortality rate reaches 75% by age 46. Cerebrovascular accidents together with congestive heart failure and aortic rupture and bacterial endocarditis represent some of the various death causes (Forbes & Gowda, 2014; Torok et al., 2015). The cardiovascular system of patients with CoA develops severe complications which manifest as hypertension and heart failure and aortic aneurysms and stroke. The key to reducing dangers for patients and enhancing prolonged survival needs both swift medical diagnosis along with surgical management. Patients require lifelong follow-up after repair because persistent hypertension and atherosclerosis can develop into severe health problems (Santos & Azevedo, 2003). Crafoord and Nylin achieved the first

successful surgical intervention in 1945. The early intervention methods proved ineffective because recoarctation occurred in more than half of the patients (Vasile et al., 2023). There are currently a number of methods for fixing heart abnormalities, from transcatheter use to surgical procedures. Early blood pressure management through beta-blockers and ACE inhibitors and ARBs (angiotensin receptor blockers) forms the basis of clinical therapy according to Strauss et al. (2023). Surgeons developed new techniques during the 1940s which led to dramatically better survival statistics permitting numerous patients to achieve adulthood. Surgical intervention creates permanent risks for patients which include coarctation recurrence together with dilated aortas and elevated blood pressure patterns thus requiring ongoing assessment programs and prompt medical intervention. Patients who have received CoA repair need ongoing medical surveillance because their heart risks persist after successful surgery. Although patient's condition improves right after the surgery, there are possibilities of post-operative complications which include hypertension besides aortic aneurysms as well as congestive cardiac failure. Such follow up care visits are important as they enable the assessment of several parameters for signs of complications through blood pressure check-ups with cardiovascular and imaging tests. It allows finding out such dangerous situations as recoarctation or acute aortic dissection when they remain treatable. Such patients need to continue using antihypertensive drugs adjusting the therapy depending on the patient's age to avoid subsequent cardiovascular diseases and their consequences in the future (Muhll et al., 2016). Coarctation of the Aorta (CoA) is therefore caused by the failure of genes and the intrauterine environment to form a normal aorta. CoA lesions are diagnosed by the presence of tissue ridges from posterior aortic wall that constrict the lumen of aorta. Intimal proliferation draws the layers of blood vessels still farther and hinders the flow of blood (Vuong & Berry, 2013). In spite of this, several authors have reported that abnormalities in the NOTCH1 gene are the major causes of CoA development, but this is not quite the whole truth. NOTCH1 gene plays a vital role in vascular formation and smooth muscle determination, and mutations abnormal affect aortic morphogenesis (Fouillade et al., 2012). Anatomical observation suggests that CoA arises from antenatal insults and from such features that condition aortic morphogenesis. Recently, with the help of zebrafish and understanding of gene-protein and developmental pathways, CoA formation became less mysterious (Tu and Chi, 2012). This study explains the biological pathways involved in the development of CoA as well as the better ways by which this condition may be diagnosed and managed.

Clinical representation

This study focuses on a 45-year-old male with the history of Coarctation of the Aorta (CoA) diagnosed during childhood. Initially there was a gradual rise in his blood pressure, which gradually become hectic at times with difficulty in breathing due to the exertion of the heart. This health deterioration was making him suffer from severe headaches at close intervals and occasional brief spells of dizziness. His blood pressure in his upper extremities was recorded as 170/100mmHG while that of the lower extremities was 120/80 mmHG which are definitive of CoA. He presented with equally diminished and delayed femoral pulses which led the doctor to establish the presence of a harsh systolic murmur in the left sternal border which was radiating through the patient's back due to turbulent blood flow via the narrowed aorta. He also felt chest compression, which might be hydrostatic pressure resulting in hypertension; weakness, which might have been linked to low blood supply to vital organs; periodic dizziness. He still had uncontrolled hypertension even after medical management hence a need for surgical management of his coarctation. The first concern of the case provides a general picture of the typical health challenges that are likely to be experienced by an individual who does not seek treatment for CoA, thus the need for early diagnosis and frequent follow-up. Specifically, cMRI was the main method employed to determine the extension and severity of the coarctation of the aorta. Also, CT scan with i.v contrast medium was carried out with a view of visualizing the vascular structures and clarity of the aortic lumen to diagnose CoA. X-ray CT examination helped to establish the location of the constriction of the aorta which is typical for this

type of congenital abnormalities. Echocardiography exam also reflects the position of the heart and the degree of the narrowed aorta, thus assisting to determine the CoA severity and effects on blood circulation and hypertension.

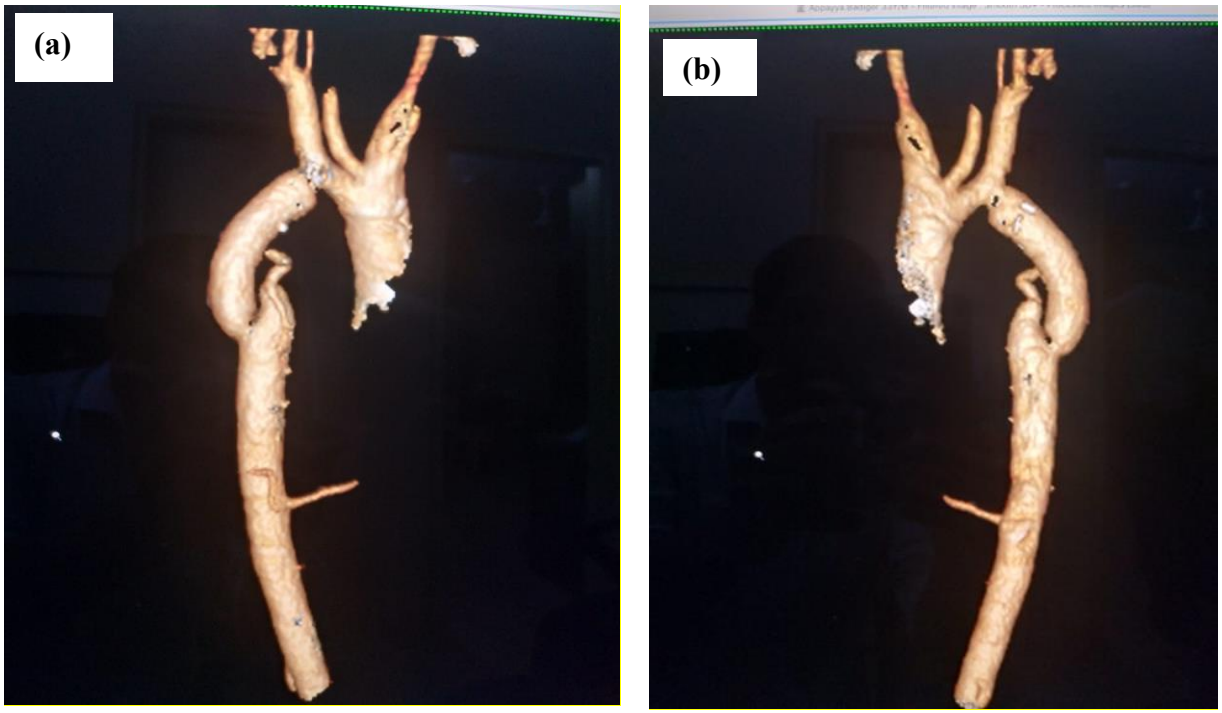


Figure 1: a) Left view Pre-Treatment 3D Imaging of Aortic Coarctation using cMRI, **b)** Right view Pre-Treatment 3D Imaging of Aortic Coarctation using cMRI**.**

The cMRI images revealed a narrowed section of the aorta which demonstrated the location of vessel constriction that leads to elevated pressure in front of the narrowing and diminished blood flow behind it Figure 1(a),(b) Left and right view.

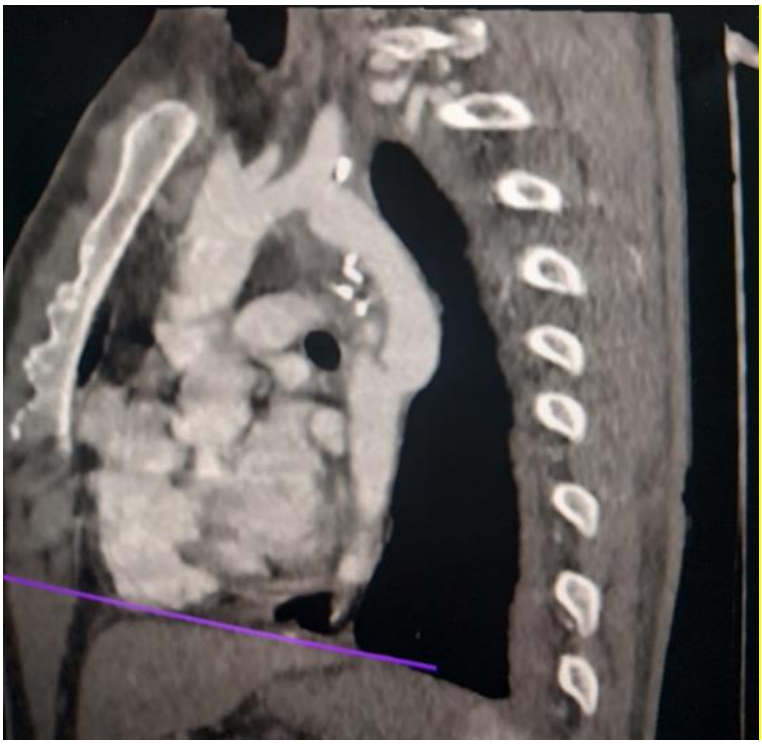


Figure 2: CT Scan Showing Aortic Coarctation Pre-Treatment

The figure 2 displays a Computed Tomography (CT) scan sagittal view which reveals the heart and aorta. The purple line appears to mark a particular measurement area. The structure suggests this observation pertains to a Coarctation of the Aorta (CoA).

The patient requires surgical treatment for Coarctation of the Aorta (CoA) that includes removing the constricted aortic segment followed by either anastomosis or graft insertion to restore regular blood circulation. The surgical team will use Cardiopulmonary bypass (CPB) to sustain circulation during the operation.

2.1 Surgical Procedure for Aortic Coarctation Treatment:

Step 1: Preparation and Exposure

The patient is positioned, and a midline sternotomy (or a similar incision) is made to expose the heart and aorta (Figure 3(a)). The surgical field is cleaned and prepared, and the chest is opened. Cardiopulmonary bypass (CPB) is set up using cannulas, which will allow the heart to be temporarily stopped during surgery while blood flow is maintained via the bypass machine**.**

Step 2: Aortic Exposure

The aorta is carefully exposed to access the site of the coarctation (narrowing). The surgical team uses retractor tools to keep the area open and allow proper visualization of the aorta. The coarcted segment is identified and prepared for correction (Figure 3(b)).

Step 3: Resection of the Coarctation

Once the narrowing is identified, the surgeon removes the narrowed portion of the aorta. This step is critical in removing the obstruction that is affecting blood flow.

Step 4: Reconstruction of the Aorta

The surgical team proceeds to reconstruct the aorta. This involves either anastomosis (connecting the two healthy ends of the aorta) or using a graft (a synthetic material or biological tissue) to bridge the gap and restore normal blood flow. The graft can be seen in the (Figure 3(c)), where it is being placed and sutured into position to replace the resected section of the aorta.

Step 5: Checking Blood Flow

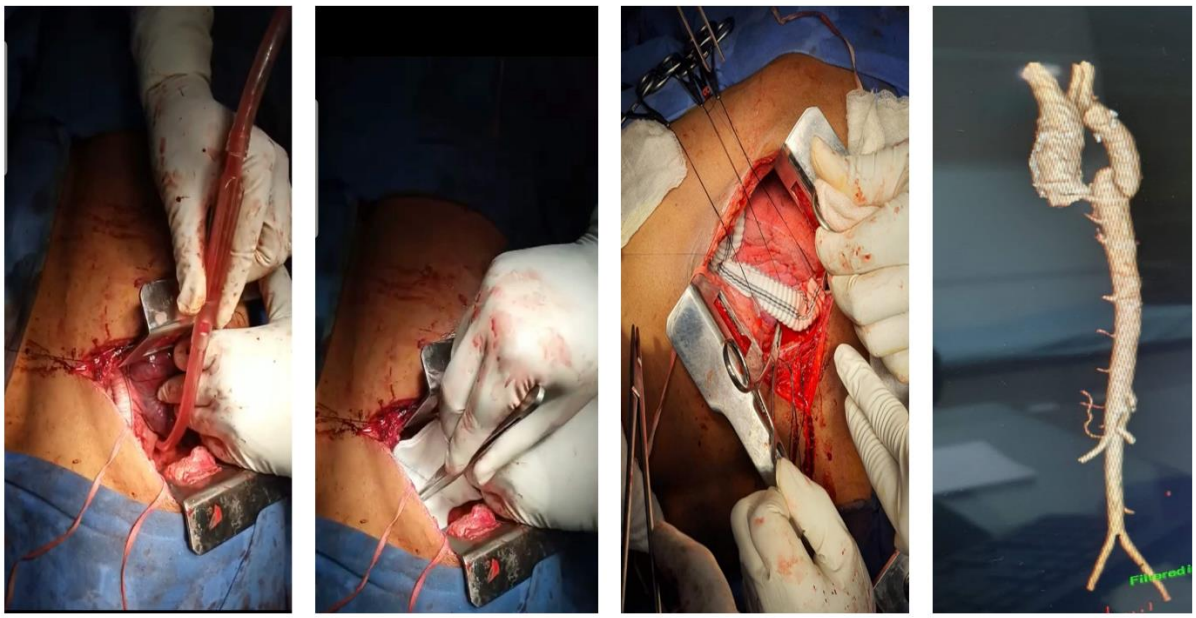
The surgical team checks for proper blood flow after the graft placement to ensure that the repair is successful. The cannula is removed from the aorta, and blood circulation is restored. And checked and confirmed with post-Treatment 3D Imaging of the Aorta After Coarctation Repair Figure 3(d).

Step 6: Closing the Surgical Site

Once the repair is confirmed, the surgical site is carefully closed. Cardiopulmonary bypass is discontinued, and the chest cavity is sutured back together.

Step 7: Postoperative Care

After the surgery, the patient is closely monitored for any complications, including infection, bleeding, or the recurrence of coarctation. Lifelong follow-up is essential for patients who undergo CoA repair, as complications like hypertension or aortic aneurysms may develop later in life.



(a) (b) (c) (d)

Figure 3: Figure 3 (a) shows the initial intraoperative view where the coarctation site is surgically exposed, allowing access to the narrowed portion of the aorta. In **Figure 3 (b)** a catheter is placed, and cannulation is performed to facilitate blood circulation during cardiopulmonary bypass, which temporarily takes over the heart's function while the surgery proceeds. **Figure 3 (c)** captures the moment when an aortic graft is surgically inserted to replace the narrowed section of the aorta, restoring normal blood flow. Finally, **Figure 3 (d)** presents a 3D imaging of the aorta post-repair, confirming that the coarctation has been successfully corrected and the aorta is now free of constriction, allowing proper circulation.

2. Discussion

Coarctation of the Aorta (CoA) represents a birth defect which becomes increasingly difficult to diagnose and treat when patients do not receive proper medical attention until they reach adulthood. The 45-year-old male patient demonstrates the typical CoA presentation through his chronic hypertension alongside headaches and chest pain which develops after prolonged cardiovascular strain. The patient's different blood pressure readings between upper and lower body parts served as a vital diagnostic sign for CoA according to Salian et al. (2024) which demonstrates typical CoA symptoms. The successful treatment of this condition depends on making a proper diagnosis immediately because delayed medical response produces harmful health complications. Despite the CoA surgical repair that is known to improve the patient’s survival rate, he or she remains at the risk of recoarctation, aortic dilation, or hypertension after the procedure (Toro-Salazar et al., 2002). Long-term follow-up is necessary for post-repair patients especially since both aneurysms and dissections present severe risks to patients’ health. Ongoing hypertension, common among CoA patients post-surgery, stems from structural aortic changes and altered blood flow post-obstruction removal (Olayiwola et al., 2023). It was highlighted that the long-term monitoring of blood pressure after operation and adequate control of the postoperative hypertension will help to minimize cardiovascular complications. Recoarctation and aortic dilation diagnosis requires high-end cardiac imaging modality such as cMRI and CT angiography (Karaosmanoglu et al., 2015). High-resolution cMRI is most often used to manage aortic diseases in patients with implanted devices or stents after coarctation of the aorta (Cavalcante et al., 2016). The current patient required cMRI to determine the dimensions of the aorta and to determine potentials threats to any long term ailments. Adult CoA management needs interventions of multiple specialties, including cardiologists, surgeons, and radiologists in most

cases due to the perennial need for consistent follow-up of cardiovascular system (Lip et al., 2012). Life long follow up should be made to check for such late complications like aortic dissection or coarctation after surgery since the risks are still present. Despite the elevation in survival of patients with CoA since the implementation of Medical management post-surgical CoA treatment is associated with an obligation of normal follow up, titration of blood pressure and particular echocardiographic imaging. Reporting an early complication in the document can lead to an improved quality of life and general healthy lifestyle among the clients.

Conclusion

As a result of the present study, it was ascertained that despite the surgical intervention in CoA, numerous adverse health conditions persist in patients afterward. This is a CoA progression, and the 45-year-old male's progression is quite standard for an adult, as the heart experiences considerable cardiovascular stress, leading to hypertension and such symptoms as chest pain and dizziness. A high prognosis is obtained from the surgical resection and grafting of tumours, thus increasing the life expectancy and improving the quality of life of affected persons. Thus, patients are at the risk of persistent hypertension, recoarctation, aortic aneurysms, and various complications that are related to heart failure; therefore, the patients need to undergo lifelong medical observation. Techniques like cardiac MRI (cMRI) and CT angiography make it possible for the hospitals to begin diagnosing complications of CoA at an early stage and draw a better treatment plan. The management of CoA should involve the combined effort of the cardiologists, surgeons, and radiologists since the patients deserve the best care efforts as expected. Thus, the patient's future health depends on appropriate maintenance of the blood pressure and regular follow-up visits due to the necessity of control and constant observation of the aorta and the cardiovascular system. Despite the fair several procedures that have been carried out to patients with CoA the process is quite a challenging one requiring constant follow up. Some of the guidelines involve frequent early assessment of complications in order to manage them and control hypertension in addition to periodic imaging to reduce the risks associated with the condition, so as to promote a better quality of life in affected persons.

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