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Hybrid Aortic Arch Replacement: A Novel Surgical Technique for a Difficult Problem

Ravi de Silva[1*], Simon Messer[1], Vimal Raj[2], Stephen Large[1]
[1]*Department of Cardiothoracic Surgery, Papworth Hospital, Cambridgeshire, UK*
[2]*Department of Radiology, Papworth Hospital, Cambridgeshire, UK*
[*]*E-mail*: *ravidesilva@nhs.net*
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Abstract

Aneurysms of the aortic arch and descending aorta are invariably fatal if left to expand, but also represent considerable surgical challenges. The development of endovascular stent grafts in combination with aortic debranching has produced results at least comparable to the more traditional surgical approach, but with considerably less co-morbidity. We describe a technique for debranching of the aortic arch without the use of circulatory support, and in doing so creating a landing zone for thoracic endovascular aneurysm repair (TEVAR). Although this procedure has been described, innovative features of our technique include transection of the left hemisternum to produce excellent surgical exposure, and ligation of the debranched arch vessels to prevent Type II endoleaks following TEVAR. Additionally, by not using mechanical circulatory support, we remove the associated pathophysiological insult, inflammatory response, and coagulopathy that is synonymous with cardiopulmonary bypass. There is also no need for circulatory arrest, with its associated perils.

Keywords: Aortic Arch, Endovascular Procedures/Stents, Off Pump Surgery

1. Introduction

Arch and descending aortic aneurysms are complex problems which have traditionally been treated with extensive surgical procedures needing circulatory support, and often a period of circulatory arrest [1,2]. The associated techniques of cerebral protection including antegrade or retrograde selective cerebral perfusion and deep hypothermia have all been showed to produce good surgical outcomes, but with little information on the cognitive outcome which is of great concern to patient and surgeon alike [3]. The use of endovascular stents and TEVAR is suitable in some descending aortic aneurysms [4], but in other cases and for arch aneurysms, there is no satisfactory landing zone to anchor the stent, without jeopardizing one or more of the arch vessels. On occasion this problem can be negotiated by landing the stent between left common carotid and left subclavian arteries. Inflow to the left subclavian artery is restored by a conduit from the left common carotid artery. Hybrid (open surgery followed by TEVAR) approaches to arch aneurysms are well reported. This is described via a median sternotomy with and without the use of cardiopulmonary bypass [5]. The arch vessels are debranched and then simply stented across. We have highlighted three main shortcomings of this approach. Firstly surgical exposure via a median sternotomy alone can be very limited for distal arch vessels, making the left common carotid and left subclavian anastamoses extremely difficult. Secondly, by leaving the debranched native arch vessels intact, there is a risk of Type II endoleak following TEVAR [6,7], with retrograde flow back into the arch aneurysm. Thirdly, cardiopulmonary bypass and its associated inflammatory, coagulopathic and pathophysiological sequelae, is a very unattractive adjunct to this type of surgery and we advocate doing this procedure off pump. Our technique utilizes a modified sternotomy for better access and ligation of individual native arch vessels to prevent future endoleaks, without mechanical circulatory support.

2. Case Report

A 69 year old ex-smoker presented with an 18 month history of dysphonia. He had been involved in a serious car accident 35 years previously, had poorly controlled hypertension, and had undergone total thyroidectomy for carcinoma 20 years ago. Investigations revealed left vo-

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cal cord palsy, and contrast enhanced computerised tomography confirmed an 8.7 cm aneurysm of the distal aortic arch (**Figure 1**). A multidisciplinary team 2-stage approach was employed. Stage one involved surgical debranching of the aortic arch, in preparation for stage two—thoracic endovascular aneurysm repair (TEVAR).

Prior to surgery the patient was anaesthetised and intubated with a single lumen endotracheal tube. Suitable peripheral and central venous access was gained for infusions and monitoring of central venous pressure. Bilateral radial and a single femoral artery lines were sited.

Following median sternotomy the ascending aorta was slung with a tape which was retracted caudally to bring the aortic arch more into view. The arch branches were then dissected out. The left subclavian artery was the first to be debranched. Access to it is invariably extremely difficult, but in this case was improved by division of the left hemisternum at the level of the first intercostal space. This incision is further extended to create a high anterior mini-thoracotomy, sacrificing of the left internal thoracic artery (LITA) in doing so. This lateral displacement of the manubrium allows for better visualisation of the first part of the subclavian artery. Ten thousand units of heparin was administered and the left subclavian artery cross clamped proximally and distally.

Figure 1. 3-D CT reconstruction of the ascending, arch and descending aorta, showing the aneurysm (A), which arises just after the aortic arch (AA) branches. The anatomy of the arch and the proximity of the aneurysm to the arch vessels precludes TEVAR without aortic Debranching.

An 8 mm vascular graft was anastamosed end-to-side to the left subclavian, after which the clamps were released and the graft de-aired.

Attention was then turned to the ascending aorta to which a side-biting clamp was applied. A 1 cm transverse aortotomy was made to which the mid-point of another 8 mm vascular graft was anastamosed in a side-to-side fashion. The graft lay perpendicular to the ascending aorta, in the line of the transverse aortotomy. The side-biting clamp was removed and the graft de-aired. The two limbs of this graft were then used to debranch the remaining arch vessels, with the right limb anastamosed to the innominate artery, and the left limb to the left common carotid artery, in an end-to-side fashion. The proximal end of the graft to the left subclavian artery was then anastamosed end-to-side to the left carotid graft. Finally the arch vessels were ligated proximal to their anastamoses with the vascular grafts, protamine administered, haemostasis secured, and the chest closed. Particular attention is given to stabilising the left hemisternum with additional sternal wires which apposed the transected portions of the hemisternum. A post-procedure CT reconstruction is shown in **Figure 2**. The patient was discharged on the fourth post-operative day to await TEVAR.

3. Conclusions

Advances in endovascular technology have revolutionized the role of surgeons in major aortic diseases such as Stamford Type B dissections, aneurysms, and transections. The ascending and arch aorta however, remains an area of difficulty, as sacrificing inflow to the arch branches by stent placement, can be catastrophic. A hybrid technique for arch debranching has previously been described [5], but we have modified this approach to address its deficiencies. Specifically these shortcomings are surgical exposure, the potential for endoleaks following TEVAR, and the need for cardiopulmonary bypass.

Exposure of a surgical site is key to a successful procedure, and we have improved access to the distal arch vessels by transection of the left hemisternum in the first intercostal space. This approach on the right hemisternum has previously been described for access to the right subclavian artery [8], and in our technique we find it gives excellent exposure of the left common carotid and left subclavian arteries.

Endoleak following TEVAR is well recognised [6,7], and type II endoleaks following arch debranching can be particularly difficult to correct, and will eventually lead to aneurysm rupture. We proximally ligate the debranched native arch vessels to prevent retrograde inflow into

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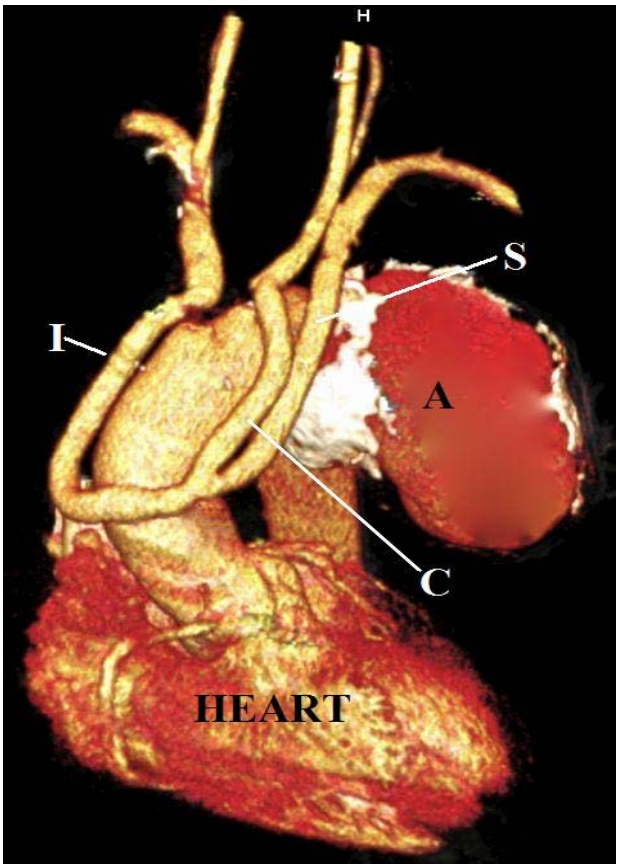

Figure 2. 3-D CT reconstruction of the ascending, arch and descending aorta, showing the aneurysm (A), and the 3 conduits anastamosed to the branches of the aortic arch (I = innominate artery conduit, C = left common carotid artery conduit, S = left subclavian artery conduit).

the aneurysm, which eliminates the risk of type II endoleaks in this area. Although ligating normal arteries would seem counterintuitive, if left patent the backflow following TEVAR will eventually leave the patient at the risk of aneurysm rupture, negating any prognostic benefit of intervention.

Our technique does not need circulatory support with its possible complications. Despite the many advantages of cardiopulmonary bypass, it can also cause significant morbidity, especially the associated inflammatory response and coagulopathy. By addressing the arch vessels sequentially, ligating the vessels only after completion of the debranching, and careful haemodynamic management by the anaesthesiologist, we have managed to do this procedure without the help of cardiopulmonary bypass. This makes the concept of hybrid surgery even more attractive than the open surgical alternative, which also requires a period of hypothermic circulatory arrest.

Overall, our modified technique of hybrid aortic debranching allows the surgeon to perform the procedure with relative ease, so that the patient may have an expeditious recovery and proceed to TEVAR.

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