Case report

Hybrid repair of aortic arch aneurysm

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Aneurysms of the transverse aortic arch requiring surgery most often affects elderly patients with multiple co-morbidities and represents a significant challenge to both patient and surgeon. The hybrid approach developed in recent years (debranching followed by endovascular repair) may improve the morbidity and mortality of the population risk. We present the case report of a 72-year-old man with aortic arch aneurysm arising at the origin of the left subclavian artery involving whole caudal segment of an aortic arch with concomitant single vessel coronary disease. The hybrid procedure was carried out in two stages, first (open surgical approach) performing an extra-anatomic bypass – debranching combining with concomitant coronary artery bypass procedure without heart-lung machine and following day deploying the aortic endograft. Postoperative period was uneventful. On the 15th day after hybrid procedure, the patient was discharged in a stabilized condition for ambulatory care. This approach may be an alternative to standard open procedures in high-risk patients with promising midterm results.

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I n t r o d u c t i o n

Thoracic aortic aneurysm is a life-threatening condition with an estimated incidence of 6–10 cases per 100,000 person-years [1]. The natural history of untreated patients with thoracic aortic aneurysms is characterized by progressive expansion and eventual rupture [2,3]. Five-year survival in patients with untreated thoracic aortic aneurysms has been estimated to range from 15% to 55% [2,3]. In the past years, conventional surgical repair has been the only therapeutic method for extensive aortic diseases. However, this approach, which uses cardiopulmonary bypass, deep hypothermic circulatory arrest, retrograde or anterograde cerebral perfusion still carries a substantial rate of mortality and morbidity; furthermore, it predicts a high incidence of permanent neurological injury in old series.

Endovascular stent-grafting has developed as a safe and effective treatment for descending aorta pathologies, and recently, even for delicate anatomic regions such as the aortic arch. However, in case of total involvement of the aortic arch, the challenge is to maintain blood flow to the brain and upper extremities that may require covering one or more aortic branches in order to establish a secure proximal landing zone, and to ensure complete exclusion of the lesion [4]. Endovascular exclusion of aortic arch pathologies combined with an open surgical component effectively called “hybrid” have been recently
introduced in an attempt to reduce morbidity and mortality [5].

Case report

A 72-year-old man with a symptomatic (dysphagia, tingling of left upper extremity) saccular aortic arch aneurysm was treated with the hybrid procedure. The lesion, with a maximum diameter of 53 mm, neck 38 mm, was located on the lateral left side of the aortic arch at the level of the origins of the left subclavian artery (Fig. 1).

Preprocedural CT angiography was done to confirm aneurysm morphology, adequacy of the iliofemoral access sites and assess the patency and dominance of the vertebral arteries as well as the anatomy of the circle of Willis in order to define what to do with the left subclavian artery (LSA).

He had history of coronary artery disease (single vessel disease), chronic renal failure, hypertension and hepatopathy and was assessed as extremely high risk for conventional open aortic arch surgery. The hybrid procedure was carried out in two single stages, first (open surgical approach) performing an extra-anatomic bypass – debranching including coronary artery bypass grafting without a pump.

After median sternotomy, the pericardium was opened and the ascending aorta was exposed in standard fashion. The brachiocephalic trunk, the left common carotid, and the left subclavian arteries were also circumferentially dissected. After systemic heparinization the ascending aorta was side-clamped, and a proximal end-to-side anastomosis was performed with a bifurcated Dacron graft using a 4-0 Prolene (Ethicon, Inc, Somerville, NJ) running suture. Consecutively the brachiocephalic trunk was then partially clamped, longitudinally opened, and an end-to-side anastomosis performed with the initial branch of the bifurcated prosthesis using 5-0 Prolene running suture. After flushing, blood flow was re-established. The brachiocephalic trunk was then ligated to prevent a type II endoleak. The left common carotid artery was then test-clamped and if no anomalies were recorded by (INVOS® System) cerebral oxymetry the artery was ligated proximally and an end-to side anastomosis done with the other branch of the bifurcated graft using a 5-0 Prolene running suture. After flushing, blood flow was re-established. Thereafter, single venous bypass to marginal branch of circumflex artery has been performed without using heart lung machine (Fig. 2).

Subsequent to the surgical procedure an endograft deployment (Valiant 38 34 160 endograft) was accomplished. Left subclavian artery was embolized by Amplatz Vascular Plug. Final angiography showed bypass patency as well as total aneurysm sac exclusion (Fig. 3).

Discussion

Hypothermic circulatory arrest is the traditional method to treat aortic arch aneurysms, but deep hypothermia is associated with prolonged extracorporeal circulation and increased mortality and morbidity rates due to microembolisation and a total body inflammatory reaction, particularly coagulopathy, respiratory distress, and renal, cardiac and endothelial dysfunction [6,7].

Many patients with aortic arch have a significant number of medical and surgical comorbidities that make their surgical options limited. A less invasive and potentially safer group of techniques using both endovascular and open technical techniques (hybrid) have been developed to offer patients treatment who might otherwise not have been operative surgical candidates using standard open surgical techniques [8].

Usually, patients presenting with multisegmental thoracic aortic pathology originating at the level of the aortic arch have an atherosclerotic etiology, which is fundamentally different when compared to patients having aortic disease in the root and the ascending aorta. This is reflected by a very high incidence of obliterative arteriopathy especially in patients with penetrating atherosclerotic ulcers (PAU). Therefore, these patients may benefit most from these combined approaches [9].

Atherosclerotic ulcers of the aortic arch are a clear sign of extensive atherosclerotic lesions involving the aorta and brachiocephalic branches of the arch. The ulcers are the clinical equivalent of aneurysms and pose, among other

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**Fig. 1** – Preprocedural computer tomography angiogram of the aorta showing the aortic arch aneurysm.
things, the risk of rupture with bleeding fatal for the patient. Urban et al. [10] described the case of a patient with two aortic arch ulcers in the presence of severe atherosclerotic lesions involving the ascending aorta and aortic arch. A hybrid approach consisting of surgical bypass of a branch of the aortic arch combined with coronary artery bypass grafting, with subsequent removal of ulcers and stent graft implantation in the aortic arch is described.

Koullias and Wheatley [11] proposed for the first time a new classification system for hybrid arch procedures (type I and type II) relating to whether the arch is surgically replaced or excluded with a stent graft. Arch pathologies that can be repaired by a hybrid procedure includes atherosclerotic aneurysms, dissections of all types (acute and chronic Type A and Type B), contained aortic arch ruptures, and penetrating ulcers and this procedure can be used in an elective and emergent setting.

In hybrid type I procedures, the foundation of this approach is that the arch should fundamentally be repaired using surgical replacement techniques using cardiopulmonary bypass and deep hypothermic arrest. The endovascular component of this approach becomes a less invasive addition to a traditional surgical approach to the arch to help complete the downstream repair of the distal arch and proximal descending thoracic aorta. This approach eliminates the need for a second operative procedure to address the diseases’ descending aorta and decrease the mortality between the first and second stage, as well as the morbidity of the second stage.

In hybrid type II procedures the endovascular repair is the primary arch repair method (meaning that the endovascular stent graft excluded the arch disease without surgically replacing the arch) and the open surgical component was an adjunctive procedure for revascularization of the great vessels. This technique in contrary with the previous one is better suited for localized disease of the aortic arch with landing zones in the normal aorta, proximally in the ascending aorta and distally in the proximal to mid-descending thoracic aorta, as it is in the case report in which it has just been reported.

In Koullias and Wheatley [11] meta-analysis the thirty-day outcomes for all hybrid arch procedures had an 8.3%
perioperative mortality which compares favorably with recent published series for open arch repair by Sundt et al. [12]. The thirty-day mortality between hybrid type I and type II procedure was 6.9% versus 10.2% and was not significantly different. However higher risk patients were in general in the type II category.

Moreover no statistical differences between type I and type II procedure patients regarding stroke or paraplegia is found (4.1% and 2.6% respectively for type I, 4.8% and 5.8% respectively for type II), also favorably compared with recently published series of Shimamura et al. [13].

Vallabhajosyula et al. [14] reported 30 day/in-hospital mortality (8%) for the entire group. Mortality was 11% for the Type I group, and zero for the Type II group. Causes of death were all secondary to neurological complications: two from spinal ischemia resulting in permanent paraplegia, and one of complications of stroke. While there have been no in-hospital deaths to date in patients with Type II hybrid arch repairs, this and all other immediate postoperative outcomes showed no significant difference between the two hybrid arch types.

This case report represents our first experience with hybrid repair of aortic arch aneurysm, so we will need to realize in future more similar operations in order to be able to compare our results with other authors.

## Conclusion

Hybrid procedures for the pathology of the aortic arch have been becoming common procedures at the centers specialized for the aortic surgery in few past decades. Limitation of our case report is that it represents our first experience with hybrid repair of aortic arch aneurysm. In conclusion it is possible that certain patients and diseases of the aortic arch are better served with a hybrid type I or type II procedure. In future, cohort of more patients will be necessary in order to determine whether hybrid repair of the aortic arch is a durable procedure.

## Conflict of interest

All authors declare no conflict of interest.

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## Ethical statement

Case report was done according to ethical standards.

## Informed consent

Patient agreed to participate in the case report.

## References


