

CASE REPORT

Hybrid Repair of an Aneurysm of the Innominate Artery

Peter-Jan Vancoillie ^{a,*}, Karen Peeters ^a, Sigi Nauwelaers ^a, Luc Stockx ^b, Geert Lauwers ^a

^a Department of Thoracic and Vascular Surgery, ZOL (Ziekenhuis Oost-Limburg), Genk, Belgium

^b Department of Medical Imaging, ZOL (Ziekenhuis Oost-Limburg), Genk, Belgium

Introduction: Innominate artery aneurysms (IAAs) are rare. They are notorious for causing thromboembolic events. Modern imaging modalities make early detection in an asymptomatic phase possible. In Kieffer group B aneurysms the origin of the innominate artery is affected. Thanks to the combination of open and endovascular techniques, off pump repair is feasible in patients with a fragile aortic arch. During this hybrid procedure the aortic arch is debranched and reinforced with a stent graft.

Report: A 73 year old white man with a history of extensive thoraco-abdominal aortic reconstructions for aneurysmal disease presented with a progressive Kieffer B IAA of 35 mm. He underwent an off pump hybrid repair. A bifurcated Dacron prosthesis was used for the debranching. The main body originated from the ascending aorta. The right limb was anastomosed to the common ostium of the right carotid and subclavian arteries. The left limb was anastomosed to the left subclavian and carotid artery. The aortic arch was reinforced with a 40 × 162 mm Zenith TX2 endoprosthesis. The endoprosthesis was inserted through a temporary conduit on the main body and deployed during rapid ventricular pacing. The endoprosthesis lined the ascending aorta distal to the debranching up to Ishimaru zone 3. The antegrade insertion prevented excessive manipulation of the aortic arch and the tortuous aorta, which was lined with mural thrombus. Post-operative computed tomography showed a patent debranching with excellent alignment of the endoprosthesis without endoleak.

Discussion: Hybrid repair of the aortic arch is well described in literature. This technique was adapted in the treatment of a Kieffer group B IAA. The tortuous aorta and mural thrombus led to the antegrade placement of the endoprosthesis through the main body of the debranched aorta. This approach seems safe and feasible.

© 2021 Published by Elsevier Ltd on behalf of European Society for Vascular Surgery. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Article history: Received 1 May 2021, Revised 22 August 2021, Accepted 1 October 2021,

Keywords: Aneurysm, Endovascular, Hybrid, Innominate Artery, Supra-aortic aneurysm, Surgery

INTRODUCTION

IAAs are classified together with subclavian and carotid aneurysms as supra-aortic aneurysms (SAAs), representing 0.4%–4% of all aneurysms.¹

They can present as a thromboembolic event: stroke, transient ischaemic attack, or upper limb ischaemia. Other presentations, besides rupture, are caused by mass effect: dysphagia, superior vena cava syndrome, hoarseness, Horner's syndrome, or a pulsatile mass.² Thanks to improved imaging techniques, SAAs are increasingly diagnosed at an asymptomatic stage.³

Hybrid repair has become an appealing solution in cases where cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest would formerly have been necessary.⁴

The hybrid repair of a Kieffer group B innominate artery aneurysm (IAA) with antegrade stent graft placement is

presented, followed by a review on the contemporary treatment modalities and the natural course of IAAs.

CASE REPORT

A 73 year old white man presented with an asymptomatic Kieffer group B IAA. He had a history of chronic kidney disease stage 3. Besides hypercholesterolaemia, age, and being male, he had no other cardiovascular risk factors. He underwent an open aortobi-iliac graft replacement for an infrarenal aortic aneurysm in 2003 and an open tube graft replacement for a Crawford type IV thoraco-abdominal aortic aneurysm with re-implantation of the coeliac trunk, the superior mesenteric artery, and the renal arteries in 2013. The graft was anastomosed proximally at the level of T8 vertebra and distally connected to the main body of the aortobi-iliac graft. Follow up consisted of a computed tomography angiogram (CTA) every 6–12 months. In a four year period (2015–2019) there was steady growth of the innominate artery from 15 mm to 35 mm. Also, ectasia of the left subclavian artery developed, from 14 mm to 20 mm. The ascending aorta was stable at 36 mm and the aortic arch grew from 36 mm to 39 mm. At this stage, the

* Corresponding author. Department of Thoracic and Vascular Surgery, ZOL (Ziekenhuis Oost-Limburg), Schiepsse Bos 6, Genk, 3600, Belgium.

E-mail address: peterjan.vancoillie@gmail.com (Peter-Jan Vancoillie).

2666-688X/© 2021 Published by Elsevier Ltd on behalf of European Society for Vascular Surgery. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

<https://doi.org/10.1016/j.ejvsf.2021.10.001>

decision was made to operate, to prevent aneurysmal complications (Fig. 1).

Elective surgery was performed after pre-anaesthesia and cardiological screening.

Intra-operatively, blood pressure was monitored by a bilateral brachial arterial line. Neuromonitoring was provided by near infrared spectrometry and bispectral index.

First stage: aortic arch debranching

The IAA was approached by a median sternotomy. Once the pericardium was opened, all supra-aortic vessels were controlled by surgical loops. Excessive manipulation of the aneurysm was avoided.

After administration of 7 500 IU heparin, the ascending aorta was side clamped and incised longitudinally. An end to side anastomosis was made with the main body of a bifurcated Dacron graft (18 × 9 mm). In advance, a temporary side branch (9 mm) was sewn onto the main body (Fig. 2), to provide endoprosthesis access.

The IAA was ligated and excised. Next, an end to end anastomosis connected the right limb of the graft to the common ostium of the right subclavian and carotid arteries. The anastomosis took 12 minutes and did not affect cerebral perfusion. Subsequently, an end to end anastomosis was made between the left limb and the left subclavian artery after proximal ligation of the latter. An end to side anastomosis connected the left carotid artery to the left limb after proximal ligation of the carotid artery. This took 14 minutes and did not affect cerebral perfusion.

Second stage: aortic arch endograft

The aortic arch was reinforced with an endograft with a diameter of 40mm and a length of 162 mm (Zenith TX2; Cook Medical, Bloomington, IN, USA). The endoprosthesis was deployed during rapid ventricular pacing through the temporary conduit on the Dacron graft over a stiff wire. It

lined the ascending aorta just distal to the Dacron graft covering the outflow of the supra-aortic vessels and ended in Ishimaru zone 3. Completion angiography showed no endoleak and excellent outflow of the debranched aortic vessels.

The patient was discharged on the fifth post-operative day after an uneventful recovery.

A CTA one month post-operatively showed a patent debranching with an excellent alignment of the stent graft without endoleak (Fig. 3).

Histology of the IAA showed degenerative tissue with atherosclerosis.

DISCUSSION

Natural history of IAA

The literature on IAA is limited and consists of approximately 135 case reports.^{2,5} There are few published larger series.^{1,2,6} An IAA is defined as a local arterial dilatation of >18 mm (dilation of $\geq 50\%$).⁷

Little is known about the natural history and epidemiology of SAAs, with available data being heterogenous. A synchronous aneurysm of the aorta is found in 42%–63% of cases.^{1,3} IAAs comprise 3%–43% of all SAAs.^{1–3,6} The aetiology is mostly degenerative. The incidence of infectious, vasculitic, and connective disease, as well as trauma, thoracic outlet, and pseudoaneurysm, is high, compared with aortic aneurysms.²

A bovine aorta is found in 35%, whereas the general incidence is between 7.1% and 21.1%.³

Thanks to earlier detection, SAAs have progressively shifted from large symptomatic to small asymptomatic lesions. Thromboembolic event incidence declined from 50.7% in 1991 to 7.4% in 2018.^{3,6}

IAAs are categorised into three groups. In group A there is no involvement of the origin of the innominate artery. In group B the origin is involved but not the aorta. In group C

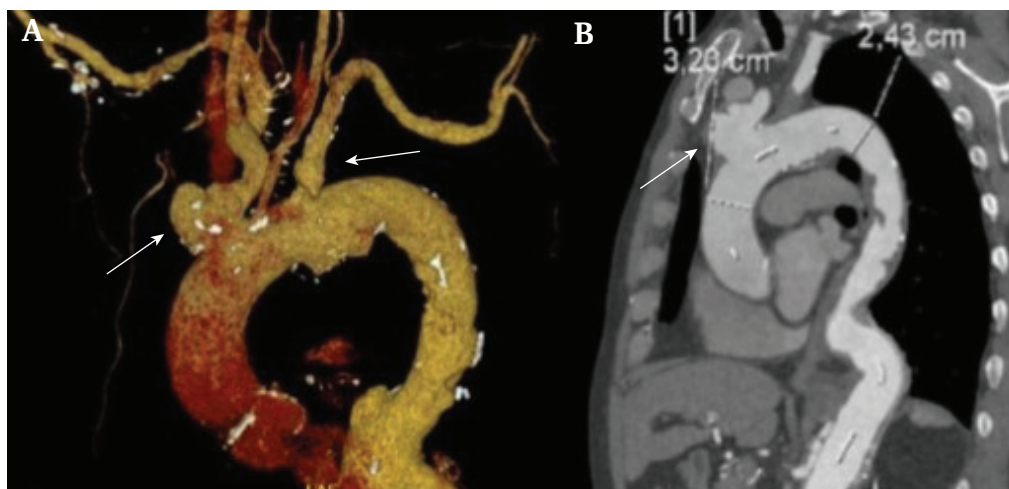


Figure 1. Three dimensional reconstruction of the pre-operative computed tomography angiogram. (A) Kieffer type B innominate artery aneurysm (IAA) and left subclavian ectasia. (B) Sagittal transection through the aortic arch and IAA. Note the mural thrombosis and the tortuous course of the descending aorta.

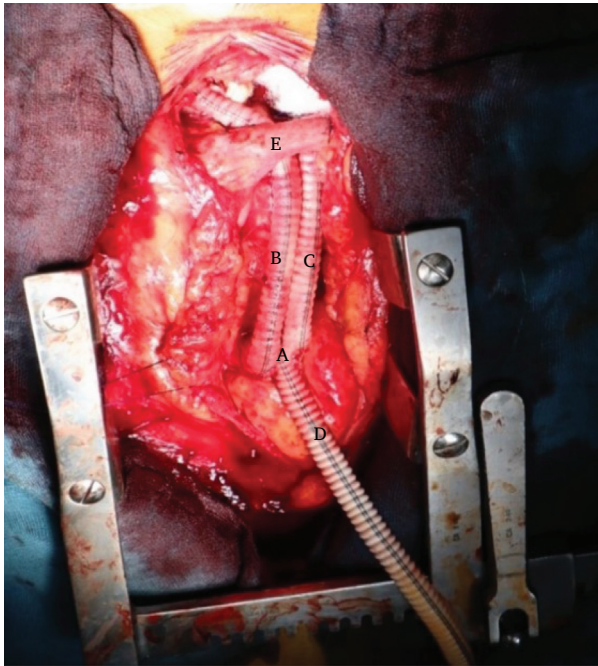


Figure 2. Status after complete debranching of the aortic arch. (A) Main body of the bifurcated graft onto the ascending aorta, (B) right limb to the right carotid and subclavian arteries, (C) left limb to the left carotid and subclavian arteries, (D) temporary side branch, and (E) innominate vein.

the origin, as well as the aorta, are involved. Most IAAs have a group B morphology.¹

Repair options

Open repair in group A aneurysms consists of an interposition graft originating from the ascending aorta, thus only requiring side clamping of the aorta. In group B aneurysms,



Figure 3. Three dimensional reconstruction of the computed tomography angiogram one month post-operatively showing an adequate position of the stent graft without endoleak and a patent debranched aorta.

cross clamping of the aorta may be necessary. This is done by first debranching the right common carotid artery via aortic side clamping. Secondly, the aorta can be safely cross clamped distal to the debranched carotid artery.¹ In group C aneurysms, aortic cross clamping and deep hypothermic circulatory arrest may be necessary.

Only group A IAAs are eligible for endovascular repair, as an adequate proximal and distal landing zone are required.⁸

A hybrid approach can reduce the risks and limitations of endovascular and surgical techniques. This makes off pump repair possible in group B aneurysms that are not eligible for repair according to Crawford.⁸

Case report

Hybrid repair is well described in aortic arch aneurysms.^{9,10} Few case reports are available on IAA. To the authors' knowledge, an antegrade approach has only been described in aortic arch pathology.¹⁰

An antegrade approach was preferable for several reasons. Firstly, no inguinal access was needed, avoiding access route injury in a patient with a bifurcated aortobi-iliac prosthesis.¹⁰ Secondly, it prevents additional wound infections. Thirdly, embolisation during a retrograde approach seemed much more likely in the tortuous aorta with mural thrombus (Fig. 1).

An endoprosthesis was not only placed to prevent dilatation, but also because of the poor tissue quality of the arch. The IAA and subclavian ectasia were ligated 1 cm distal to their origin. A lateral (reinforced) suture or patch angioplasty of these vessels would have required clamping of the arch, which possibly could have led to rupture or embolisation.

Recent recommendations (European Society for Vascular Surgery consensus) for the treatment of aortic arch pathology state that a hybrid approach is a valid option when aortic cross clamping is to be avoided. As recommended, a proximal and distal landing zone with a length of ≥ 25 mm and a diameter of < 38 mm was present. A retrograde approach is discouraged in case of unfavourable aortic lumen characteristics.⁴

There is no consensus on the repair of asymptomatic IAAs. Cury et al. found that small aneurysms have the biggest risk of a thromboembolic event.² Kieffer et al. advocate a prompt IAA repair in case of a concomitant aortic aneurysm or a saccular aneurysm or when the diameter exceeds 30 mm.¹ Brownstein et al. state that the natural course of SAAs is mostly benign.³ They have a slow growth rate with no rupture or thrombo-embolic events after a follow up of 52 months.³ For small asymptomatic aneurysms, observational management is justified, according to the latter.

CONCLUSIONS

IAAs are rare and often found by chance. Little is known about their natural history. They can present with a thromboembolic event. Repair is indicated in symptomatic lesions or lesions > 30 mm. The hybrid repair of a Kieffer type B IAA in a patient with a hostile thoraco-abdominal

aorta is presented. This case is remarkable because the aortic arch stent graft was positioned in an antegrade fashion. This approach proved to be safe and feasible.

FUNDING

None.

CONFLICTS OF INTEREST

None.

ACKNOWLEDGEMENTS

This paper was presented during the Belgian Surgical Week 2020. This annual congress was held online on 25 November 2020. The authors acknowledge Herman Schroë for the proof reading of the manuscript.

REFERENCES

- 1 Kieffer E, Chiche L, Koskas F, Bahnini A. Aneurysms of the innominate artery: surgical treatment of 27 patients. *J Vasc Surg* 2001;**34**:222–8.
- 2 Cury M, Greenberg RK, Morales JP, Mohabbat W, Hernandez AV. Supra-aortic vessels aneurysms: diagnosis and prompt intervention. *J Vasc Surg* 2009;**49**:4–10.
- 3 Brownstein AJ, Rajaei S, Erben Y, Li Y, Rizzo JA, Lyall V, et al. Natural history of aneurysmal aortic arch branch vessels in a single tertiary referral center. *J Vasc Surg* 2018;**68**:1631–9.
- 4 Czerny M, Schmidli J, Adler S, van den Berg JC, Bertoglio L, Carrel T, et al. Editor's Choice — Current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch: an expert consensus document of the European Association for Cardio-Thoracic Surgery (EACTS) and the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2019;**57**:165–98.
- 5 Wang XL, Guan XL, Jiang WJ, Liu O, Zhang HJ. Innominate artery aneurysm, how to solve it? *J Int Med Res* 2017;**45**:1279–84.
- 6 Bower TC, Pairolero PC, Hallett JW, Toomey BJ, Gloviczki P, Cherry KJ. Brachiocephalic aneurysm: the case for early recognition and repair. *Ann Vasc Surg* 1991;**5**:125–32.
- 7 Kahraman H, Ozaydin M, Varol E, Aslan SM, Dogan A, Altinbas A, et al. The diameters of the aorta and its major branches in patients with isolated coronary artery ectasia. *Tex Hear Inst J* 2006;**33**:463–8.
- 8 Chambers CM, Curci JA. Treatment of nonaortic aneurysms in the endograft era: aneurysms of the innominate and subclavian arteries. *Semin Vasc Surg* 2005;**18**:184–90.
- 9 Andr asi TB, Grossmann M, Zenker D, Danner BC, Sch ondube FA. Supra-aortic interventions for endovascular exclusion of the entire aortic arch. *J Vasc Surg* 2017;**66**:281–97.
- 10 Yamamoto K, Komori K, Narita H, Morimae H, Tokud Y, Araki Y, et al. A 'through-and-through bowing technique' for antegrade thoracic endovascular aneurysm repair with total arch debranching: a technical note and the initial results. *Eur J Cardiothorac Surg* 2016;**49**:1264–9.