Modified Arch-First Technique Performed on a Beating Heart for an Arch Aneurysm with Atheromatous Plaques

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A shaggy aorta with unstable atheromatous plaques has a high risk of neurologic complications in cases of arch aneurysm. We report the use of a modified arch-first technique involving arch replacement for a beating heart after reconstruction of supra-aortic vessels while maintaining normal blood pressure. The procedure was performed in a patient who had an arch aneurysm, complicated by an aberrant right subclavian artery (ARSA) and a shaggy aorta ascending to the aortic arch. This modified arch-first technique is an alternative surgical approach that is used for arch aneurysms involving a shaggy aorta, in order to prevent embolic debris-related complications.

Keywords: arch aneurysm, arch-first technique, aberrant right subclavian artery

INTRODUCTION

The choice of operative strategy for arch aneurysms has recently been expanded by the introduction of endovascular stent-graft treatment. Selective antegrade cerebral perfusion has become a mainstream method for brain protection during arch replacement. However, the site of aortic cannulation and the reconstruction of arch vessels vary at each institution. The arch-first technique has been widely performed for arch replacement in order to prevent cerebrovascular complications. Reconstruction of the supra-aortic vessels in the arch-first technique is generally performed under circulatory arrest or retrograde cerebral perfusion. Bypass from the ascending aorta to the 3 arch vessels to create a satisfactory proximal landing zone for thoracic endovascular aortic repair (TEVAR), called the “total debranching” procedure, has been performed on a beating heart without cardiopulmonary bypass. We report a modified arch-first technique in which this total reconstruction of the arch vessels was performed on a beating heart while maintaining normal blood pressure, to treat an arch aneurysm complicated by an aberrant right subclavian artery (ARSA) and a shaggy aorta on the aortic arch.

CASE REPORT

The patient was a 76-year-old man who had presented with hoarseness of voice and a saccular aneurysm on the distal aortic arch; the aneurysm had been identified by computed tomography (CT) angiography and was located on the minor curvature, contralateral to ARSA (Fig. 1). The ascending aorta was found to be dilated to 50 mm and the sinotubular junction (STJ) to 42 mm; mild aortic insufficiency was noted. In addition, a shaggy aorta was seen, with unstable plaques stretching from the ascending aorta to the aortic arch (Fig. 1). Coronary angiography demonstrated 75% stenosis of the proximal left anterior descending artery. The patient’s history included cerebral infarction that had occurred 2 years earlier; he had been diagnosed with artery-to-artery embolism but had
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the RCCA under a simple clamp by using the distal branch of the Gelweave Trifurcate® graft (Vascutek Terumo, Renfrewshire, Scotland, UK). The simple clamp time was 9 minutes. The RCCA was perfused at a rate of 400 mL/min from the first branch of the Gelweave Trifurcate® graft, with cooling to approximately 34°C by partial cardiopulmonary bypass from right atrial venous drainage. The LCCA was then reconstructed under a simple clamp using the second branch of the Gelweave Trifurcate® graft. The simple clamp time was 7 minutes. The RCCA and LCCA were perfused at a rate of 600 mL/min. Finally, selective cerebral perfusion was established, increasing cerebral perfusion to 800 mL/min after a catheter was inserted into the cut LSA. During the reconstruction of the 3 arch vessels, we maintained normal blood pressure in the beating heart under selective cerebral perfusion by partial cardiopulmonary bypass cooling to approximately 34°C. During the anastomoses of the neck vessels with a simple clamp, blood pressure was maintained at an average systolic pressure of 90 mmHg to maintain regional cerebral oxygen saturation within a 10% margin of decrease. In addition, we planned cerebral perfusion using perfusion catheter during anastomoses to the RCCA and LCCA with a simple clamp, if regional cerebral oxygen saturation had significantly decreased. After the isolation of the RCCA, LCCA, and LSA from the arch vessels, the core was rapidly cooled to 28°C by systemic perfusion via graft anastomosis to the RAxA, and circulatory arrest in the lower body was established (Fig. 2). The ascending aorta was transected to the aortic arch and perfusion (200 mL/min) from the RSA was restarted after closure of the ARSA origin located on the side contralateral to the saccular aneurysm. The descending aorta was trimmed, distal anastomosis was performed using the Gelweave® 4-branch 28-mm graft (Vascutek Terumo, UK), and cardiopulmonary bypass was restarted through a lateral branch. Selective perfusion was stopped after the LSA was reconstructed using the third branch of the 4-branch graft and the proximal Gelweave Trifurcate® graft was anastomosed to the first branch of the 4-branch graft while performing cerebral perfusion. We attached the main body of the Gelweave Trifurcate® graft 28 mm of 4 cm to the aortic root and performed STJ plication to create a U-shaped horizontal mattress with an external felt strip. After the graft-to-graft anastomosis, aortic declamping was performed. The graft anastomosed to the RAxA was derived to the superior mediastinum through an intercostal space and anastomosed with the completely recovered without any paralysis.

We selected total arch replacement by median sternotomy because of the presence of an unstable atheromatous plaque on the aortic arch and dilatation of the ascending aorta, including the STJ. The site of arterial cannulation and method for cerebral perfusion were discussed. We used the right axillary artery (RAxA) via graft anastomosis, instead of the proximal ascending aorta or femoral artery, as the site of arterial cannulation. However, this case was complicated by the ARSA and the risk of unstable atherosclerotic embolism from the aortic arch was still high under systemic perfusion via the RAxA. Therefore, we isolated the right common carotid artery (RCCA), left common carotid artery (LCCA), and left subclavian artery (LSA) from the aortic arch to prioritize the establishment of selective cerebral perfusion before starting total systemic perfusion, while maintaining normal blood pressure. Thus, we performed the modified arch-first technique on a beating heart.

After stand-by cardiopulmonary bypass via a graft anastomosis to the RAxA, we anastomosed the graft to the RCCA under a simple clamp by using the distal branch of the Gelweave Trifurcate® graft (Vascutek Terumo, Renfrewshire, Scotland, UK). The simple clamp time was 9 minutes. The RCCA was perfused at a rate of 400 mL/min from the first branch of the Gelweave Trifurcate® graft, with cooling to approximately 34°C by partial cardiopulmonary bypass from right atrial venous drainage. The LCCA was then reconstructed under a simple clamp using the second branch of the Gelweave Trifurcate® graft. The simple clamp time was 7 minutes. The RCCA and LCCA were perfused at a rate of 600 mL/min. Finally, selective cerebral perfusion was established, increasing cerebral perfusion to 800 mL/min after a catheter was inserted into the cut LSA. During the reconstruction of the 3 arch vessels, we maintained normal blood pressure in the beating heart under selective cerebral perfusion by partial cardiopulmonary bypass cooling to approximately 34°C. During the anastomoses of the neck vessels with a simple clamp, blood pressure was maintained at an average systolic pressure of 90 mmHg to maintain regional cerebral oxygen saturation within a 10% margin of decrease. In addition, we planned cerebral perfusion using perfusion catheter during anastomoses to the RCCA and LCCA with a simple clamp, if regional cerebral oxygen saturation had significantly decreased. After the isolation of the RCCA, LCCA, and LSA from the arch vessels, the core was rapidly cooled to 28°C by systemic perfusion via graft anastomosis to the RAxA, and circulatory arrest in the lower body was established (Fig. 2). The ascending aorta was transected to the aortic arch and perfusion (200 mL/min) from the RSA was restarted after closure of the ARSA origin located on the side contralateral to the saccular aneurysm. The descending aorta was trimmed, distal anastomosis was performed using the Gelweave® 4-branch 28-mm graft (Vascutek Terumo, UK), and cardiopulmonary bypass was restarted through a lateral branch. Selective perfusion was stopped after the LSA was reconstructed using the third branch of the 4-branch graft and the proximal Gelweave Trifurcate® graft was anastomosed to the first branch of the 4-branch graft while performing cerebral perfusion. We attached the main body of the Gelweave Trifurcate® graft 28 mm of 4 cm to the aortic root and performed STJ plication to create a U-shaped horizontal mattress with an external felt strip. After the graft-to-graft anastomosis, aortic declamping was performed. The graft anastomosed to the RAxA was derived to the superior mediastinum through an intercostal space and anastomosed with the completely recovered without any paralysis.

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caused by unstable atheromatous plaques to be high. 7) We use a modification of the arch-first technique in that we performed it under circulatory arrest by isolating the RCCA, LCCA, and LSA from the aortic arch to prioritize the establishment of selective cerebral perfusion before starting total systemic perfusion from the right axillary artery (RAxA), while maintaining normal blood pressure. 8) We believe that it is important to perform reconstruction of all 3 arch vessels under a simple clamp on a beating heart to maintain regional cerebral oxygen saturation within a margin of 10% decrease.

**DISCUSSION**

Zone 0 TEVAR involving the placement of a stent graft into the ascending aorta combined with reconstruction of 3 arch vessels has recently been performed on a beating heart for arch aneurysms and has attracted attention as a particularly effective method for high-risk patients. 5) However, TEVAR has anatomical limitations in cases wherein features such as dilation of the ascending aorta or an unstable atherosclerotic shaggy aorta are seen. The Kommerell diverticulum, which originates in the ARSA, is known to be involved in aneurysm formation. 6) The strategies for cerebral perfusion and arch vessel reconstruction, including the choice of the arterial cannulation site, are controversial and should be determined preoperatively for cases involving a distal aneurysm with a shaggy aorta and an ARSA.

In this case, we planned to use the arch-first technique because we considered the risk of cerebral embolism caused by unstable atheromatous plaques to be high. 7) We use a modification of the arch-first technique in that we performed it under circulatory arrest by isolating the RCCA, LCCA, and LSA from the aortic arch to prioritize the establishment of selective cerebral perfusion before starting total systemic perfusion while maintaining normal blood pressure. During anastomoses to the neck vessels with a simple clamp, blood pressure was maintained at an average systolic pressure of 90 mm Hg, with monitoring of regional cerebral oxygen saturation. 8) We believe that it is important to perform reconstruction of all 3 arch vessels under a simple clamp on a beating heart to maintain regional cerebral oxygen saturation within a margin of 10% decrease.

**CONCLUSION**

The modified arch-first technique on a beating heart provides an alternative surgical option that can be used for patients who have arch aneurysms and a shaggy aorta, in order to prevent embolic debris-related complications.

**DISCLOSURE STATEMENT**

All of the authors declared no conflict of interest.
REFERENCES


