Functional brain isolation technique for stroke prevention in thoracic endovascular aortic repair

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Abstract

To prevent embolic stroke during thoracic endovascular aortic repair, we have adopted the brain isolation technique since June 2014 in nine selected high risk patients (9/134: 6.7%) having ulcerated or protruding atheromas within the proximal aorta. Cardiopulmonary bypass was used to prevent aortic atheromas from entering the brain. We used a heparin-coated closed-loop cardiopulmonary bypass system incorporating a soft reservoir bag with 1 mg/kg heparin to minimize the disadvantages of extracorporeal circulation. The bypass graft (right axillary-left carotid-left axillary) was used as an arterial inflow in patients undergoing zone-1 landing (n=8), while peripheral cannulation into three brachiocephalic arteries was employed in the remaining patient. Initial pump flow was set at 1.3 L/min/m^2, and native cardiac output was reduced by adjusting the reservoir bag volume. Aortography was performed to confirm non-visualization of the arch vessels before catheter manipulation. There was no mortality and one solitary left cerebellar infarction. (147 words)

Key words: thoracic endovascular aortic repair, shaggy aorta, stroke, isolated cerebral perfusion

Introduction

In patients having severe aortic arch atherosclerosis, thoracic endovascular aortic repair (TEVAR) entails a risk of embolic stroke due to dislodgement of aortic atheromas through wire and device manipulation. In open aortic arch repair, we have been successful in preventing embolic stroke by the brain isolation technique, in which cardiopulmonary bypass is used to isolate brain circulation from the systemic one, to prevent aortic atheromas from entering the brain [1,2]. Since June 2014, we have adopted this technique during TEVAR in nine selected high risk patients (6.7%; 9/134). The indication was the presence of grade-5 (ulcerated or protruding) atheromas [3] within the proximal aorta on preoperative computed tomography.

Patients and methods

This study was approved by the institutional review board (20-153, 6th August 2020) and written informed consent was waived.

In patients undergoing zone-1 TEVAR (n=8), we performed bypass grafting from the right axillary artery to the left common carotid artery (end to end) and the left axillary artery (end to side) using an 8-mm ring-supported expanded polytetrafluoroethylene (ePTFE) graft. We used this graft as an arterial inflow and occluded the left subclavian artery using a balloon-tipped catheter (Figure 1A). A venous drainage cannula was

introduced through the right femoral vein. A closed-loop circuit incorporating a soft reservoir bag was used as a cardiopulmonary bypass equipment [4]. The priming volume was 1.3 L. The entire circuit was heparin-coated, and the heparin dosage was reduced to 1mg/kg. Cardiotomy suction was not used and activated clotting time as low as 250 seconds was allowed [5]. Initial flow rate was set at 1.3 L/min/m2, which is expected to exceed the sum of blood flow to the brain and upper limbs. Blood volume drained into the reservoir bag was adjusted to reduce the native cardiac output. Mean arterial pressure was kept constant, while small pulse pressure was maintained. Final flow was 2.1-3.5 L/min. Catheter manipulation was started after non-visualization of the arch vessels was confirmed by aortography (Figure 1B). The left subclavian artery was coil-embolized after TEVAR was completed.

In the remaining patient undergoing zone-3 landing, three brachiocephalic arteries were peripherally cannulated for arterial inflow. This technique has previously been reported in detail [6].

Results

Extracorporeal circulation time was 57 ± 14 minutes. There was no mortality. One patient developed solitary left cerebellar infarction. We speculate that an embolus was generated during balloon occlusion or coil embolization of the atheromatous left

subclavian artery (Figure 2). During follow-up, all the bypass grafts remained patent without complications.

Discussion

Aortogenic embolic strokes are frequently distributed to multiple vascular territories. The only one stroke in this cohort was solitary, and no patients with grade-4 or less atheromas (n=125) developed stroke. These results seem to justify our patient selection strategy.

Theoretically, this technique will eliminate aortogenic embolic stroke, as long as the balance between native cardiac output and pump flow is adequate. Use of a reservoir is essential to achieve this goal. We used a soft reservoir bag incorporated in a closed-loop circuit. This system allowed low level anticoagulation without hyperfibrinolysis when cardiotomy suction was not used [5], so that suture-hole bleeding through the ePTFE graft was not a problem. Temporary left carotid occlusion for bypass grafting was well tolerated thanks to ischemic preconditioning with near-infrared cerebral oximetry. The merits and demerits of this technique should be evaluated in comparison to the filtering devices that may carry the risk of generating emboli during installation.

Conflict of interest: none declared.

Legends

Figure1. Operative schema (A), aortography (B), and postoperative 3-dimensional computed tomography (C).

Figure 2. Postoperative diffusion-weighted brain magnetic resonance imaging (A) and preoperative computed axial tomography (B, C) of the patient who developed solitary cerebellar infarction.

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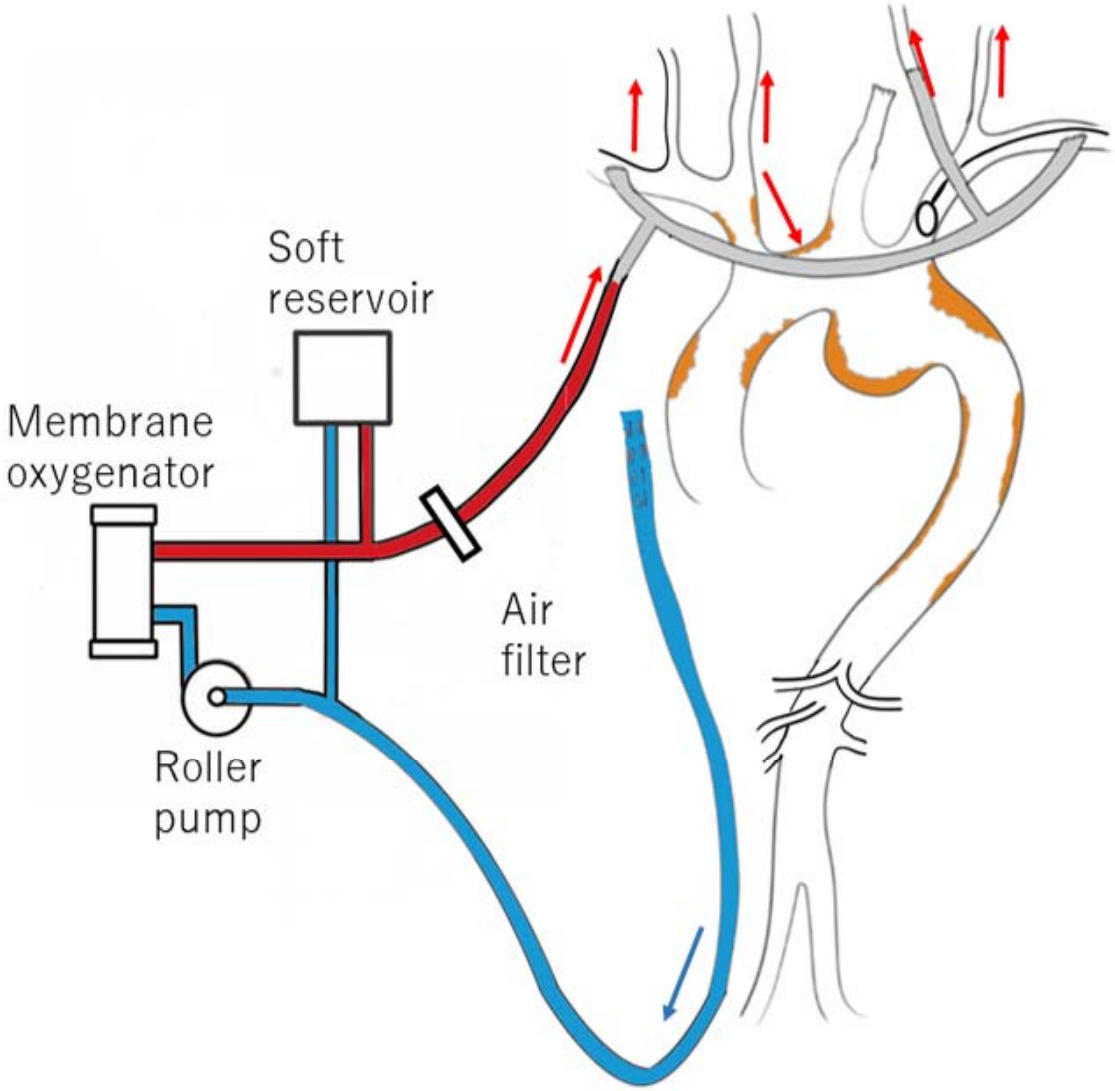
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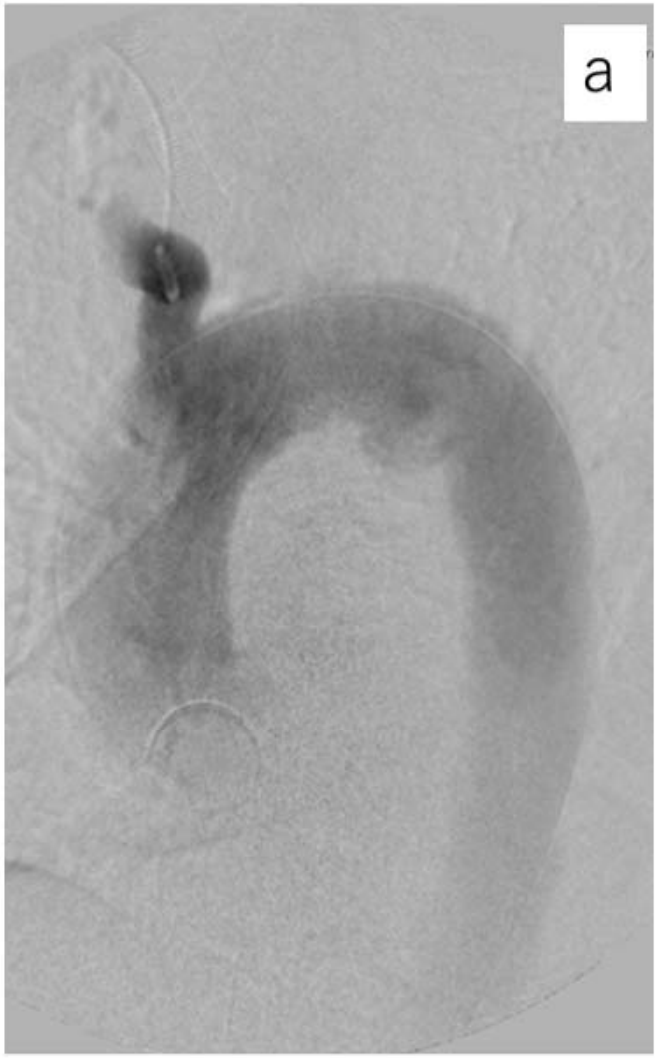
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