The aortic balloon occlusion technique in total arch replacement with frozen elephant trunk

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Abstract

The total aortic arch replacement with frozen elephant trunk is increasingly being used. However, deep hypothermic circulatory arrest is inevitable. We performed a novel surgical technique, the ‘aortic balloon occlusion’, in the surgical treatment of Stanford type A aortic dissection to reduce the adverse effects caused by deep hypothermic circulatory arrest.

Keywords: Aortic balloon occlusion • Deep hypothermic circulatory arrest • Frozen elephant trunk

INTRODUCTION

Total aortic arch replacement with frozen elephant trunk (FET) has gained popularity since it was introduced for the treatment of type A aortic dissection [1]. However, deep hypothermic circulatory arrest (DHCA) is inevitable, and some studies have shown its adverse effects, such as increased systemic inflammatory response, subsequent coagulation disorders and organ dysfunction [2]. Herein, aortic balloon occlusion technique was introduced and performed with significant outcomes in our centre.

TECHNIQUE

Assembly of the aortic balloon occlusion device

Before surgery, the tetrafurcate graft (Terumo, Vasctek Limited, Renfrewshire, UK) should be trimmed, and the aortic balloon (Coda Balloon Catheter, Cook Incorporated, Bloomington, IN, USA) in a sheath (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA) was passed through the graft to facilitate distal anastomosis of the arch (Fig. 1A).

Arterial cannulation and aortic root procedures

Using conventional median sternotomy, the right axillary artery and the femoral artery were cannulated for cardiopulmonary bypass (CPB), and the right axillary artery was used for antegrade-selective cerebral perfusion. During the cooling phase, aortic root procedures were done, if necessary.

Hypothermic circulatory arrest

Circulatory arrest was instituted when the nasopharyngeal temperature reached 28°C. Meanwhile, antegrade-selective cerebral perfusion was started at a rate of approximately 5–8 ml/(kg·min). The aortic arch was transected between the left common carotid and left subclavian arteries to avoid recurrent laryngeal nerve injury.

Stented graft release

The stented elephant trunk (Cronus, MicroPort Endovascular Shanghai Co, Ltd, China) was inserted into the true lumen of the descending aorta.

Application of aortic balloon occlusion device

The aortic balloon with the sheath was deployed into the metal part of the stented graft (Fig. 1B). After the injection of 40–45 ml of saline into the balloon, the inflated balloon was pressed by the sheath to avoid displacement (Fig. 1C).

Reperfusion of the lower body

Once the balloon was fixed, perfusion of the lower body was resumed through the femoral artery, and circulatory arrest time was decreased to approximately 5 min (Fig. 1D). The CPB flow was gradually returned to one half of full rate.
Distal arch anastomosis and the removal of the balloon

After the descending aorta was anastomosed to the 4-branched prosthetic graft, the balloon and sheath were removed. Then, proximal end of the tetrafurcate graft was clamped.

Epiaortic vessel reconstruction and proximal arch anastomosis

The left common carotid artery was reconstructed first, after which CPB flow was returned to normal and rewarming was

Figure 1: (a) Composition of the aortic balloon occlusion device. (B) The balloon in a sheath is positioned at the metal part of the stented graft. (C) The inflated balloon is pressed by the sheath to avoid displacement. (D) The perfusion of the lower body is resumed through the femoral artery along with antegrade-selective cerebral perfusion through the right axillary artery.

Video 1: Aortic balloon occlusion technique in total arch replacement and frozen elephant trunk.
begun; this was then followed by the ascending aorta, the left subclavian and innominate arteries.

To date, we have performed this procedure in 60 patients. The average DHCA time was 5.36 ± 2.78 min.

COMMENTS

Although DHCA with antegrade-selective cerebral perfusion has been confirmed to be a safe and effective method of cerebral protection [3], total aortic arch replacement with FET is still a high-risk procedure [4]. We designed and assembled the balloon occlusion device which ingeniously took advantage of the stented graft of FET, avoiding DHCA by blocking the blood flow from the femoral perfusion. Also, circulatory arrest time was shortened to approximately 5 min compared to the previous average of 20–25 min. So the desired temperature was set at 28°C; whether it could be set at a higher temperature needs to be determined in the future study.

The key points of the technique lie in the fixation of the balloon at the metal part of the stented graft which produces a restrictive effect, and using the sheath to generate thrust to the balloon to resist distal perfusion pressure.

Generally, the true lumen can be perfectly sealed if the balloon is properly positioned at the metal part of the elephant trunk and fully inflated. Sometimes, blood flows out of the large false lumen. This could be solved by adjusting the flow rate from CPB and suctioning the blood away.

Using this technique, total aortic arch replacement with FET could be performed with moderate hypothermia and transient circulatory arrest. However, further study is required on whether this technique could provide a protective effect of the central nervous system, haematological system and visceral organs.

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REFERENCES

[1] Liu ZG, Sun LZ, Chang Q, Zhu JM, Dong C, Yu CT et al. Should the “elephant trunk” be skeletonized? Total arch replacement combined with stented elephant trunk implantation for Stanford type A aortic dissection. J Thorac Cardiovasc Surg 2006;131:107–13.

[2] Urbanski PP, Lenos A, Bougioukakis P, Neophytou I, Zacher M, Diegeler A. Mild-to-moderate hypothermia in aortic arch surgery using circulatory arrest: a change of paradigm? Eur J Cardiothorac Surg 2012;41:185–91.

[3] Cefarelli M, Murana G, Surace GG, Castrovinci S, Jafrancesco G, Kelder JC et al. Elective aortic arch repair: factors influencing neurologic outcome in 791 patients. Ann Thorac Surg 2017;104:2016–23.

[4] Martens A, Beckmann E, Kaufeld T, Umminger J, Fleissner F, Koigeldiyev N et al. Total aortic arch repair: risk factor analysis and follow-up in 199 patients. Eur J Cardiothorac Surg 2016;50:940–8.