Aortic Arch Reconstruction Using a Trifurcated Graft

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Cerebral protection and prevention of atheroembolism remain challenges in aortic arch reconstruction. To reduce neurologic complications, we developed a "no-touch" technique in which a trifurcated graft is anastomosed to the arch vessels during hypothermic circulatory arrest, reducing the risk of embolization while minimizing cerebral ischemia by permitting antegrade cerebral perfusion as arch reconstruction is completed.

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Neurologic injury due to atheroembolism or global ischemia is a frequent cause of morbidity after aortic reconstruction. The standard technique for arch reconstruction has involved arch replacement with a single graft to which the orifices of the arch vessels, with a surrounding "island" of aorta, were anastomosed during deep hypothermic circulatory arrest. To reduce cerebral ischemia, the technique was modified: during circulatory arrest the patch of arch vessels was anastomosed to a smaller graft, which was then perfused in antegrade fashion while the remainder of the arch was reconstructed [1]. This technique permitted a shorter period of circulatory arrest by allowing for antegrade cerebral perfusion, but atheroembolism from diseased arch tissue remained problematic.

Recently, we developed a "no-touch" technique for arch reconstruction in which a trifurcated graft is anastomosed directly to the arch vessels during hypothermic circulatory arrest. This technique reduces the risk of embolization by excluding diseased aortic arch tissue and minimizes cerebral ischemia by permitting sequential, antegrade perfusion of the arch vessels as arch reconstruction is completed.

Technique

A median sternotomy is performed with extension of the incision superiorly along the medial border of the left sternocleidomastoid muscle. The recurrent laryngeal nerve is preserved as the aortic arch and branches are exposed. A no-touch technique of dissection is performed to reduce atheroembolism. We strictly avoid manipulating the arch at all times until the arch vessels have been severed. In a sense, the patient "is dissected away from the aneurysm."

Cardiopulmonary bypass is commenced using the right axillary artery and the right atrium, with a perfusate temperature of 22°C and quickly cooled to 10°C. Examination of the aortic arch with transesophageal echocardiography confirms retrograde flow in the innominate artery and monitors for localized dissection. When the heart fibrillates, 60 mEq of KCl is added to the pump perfusate to produce diastolic cardiac arrest and the aorta is cross-clamped. Cardioplegia and topical hypothermia are used for myocardial protection. If cross-clamping the aorta is not possible because of severe atherosclerotic debris, profound hypothermia is used with the heart vented.

After carefully sizing the innominate, left carotid, and left subclavian arteries, a trifurcated graft is constructed. Generally, 14- and 10-mm grafts or 12- and 8-mm grafts are selected. The smaller graft is divided, beveled, and, using 4-0 polypropylene sutures, a trifurcated graft is constructed as illustrated in Figure 1.

The head is packed in ice to prevent rewarming during the ischemic period. Sufficient cerebral metabolic suppression is achieved when the esophageal temperature reaches 11° to 14°C, and jugular bulb blood oxygen saturation exceeds 95%. At this point, the patient is placed in the Trendelenburg position to prevent air entrapment during circulatory arrest.

At the beginning of circulatory arrest, the innominate artery is transected just distal to its origin or at the level where arteriosclerosis is minimal. The large limb of the trifurcated graft is trimmed and anastomosed with 4-0 polypropylene suture. Great care is taken when tightening the suture line, as the brachiocephalic vessels can tear easily. The common carotid and left subclavian artery anastomoses are constructed in a similar fashion (Fig 2). Each anastomosis takes 6 to 10 minutes depending on exposure. In some patients, reversing the order of anastomoses may provide better exposure to the left subclavian artery. Perfusion through the right axillary artery is recommenced and the proximal portion of the trifurcated graft is clamped, restoring perfusion to the head and upper extremities (Fig 2). Perfusion pressure is

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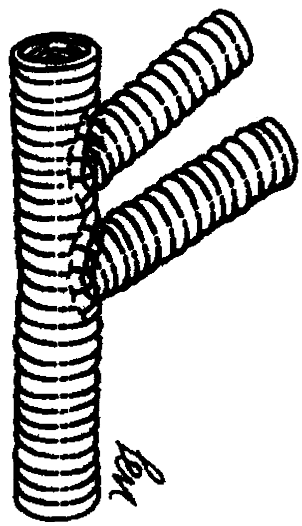

Fig 1. Construction of the trifurcated graft.

maintained at around 50 mm Hg, requiring flows between 600 and 1000 mL/min. Blood temperature is allowed to increase slowly.

Depending on the pathology, the proximal aorta may be reconstructed in a variety of ways, eventually reestablishing continuity between the ascending and descending aorta with an interposition graft.

The interposition graft is distended with cardioplegia solution to facilitate choosing the ideal site for anastomosing the trifurcated graft (Fig 3). This anastomosis can be constructed without interrupting cerebral and upper extremity perfusion.

Comment

The trifurcated graft technique of arch replacement evolved from an approach in which an "island" of aortic tissue containing the origins of the arch vessels was anastomosed to a graft. These modifications were made in hopes of reducing neurologic and hemorrhagic complications associated with arch replacement.

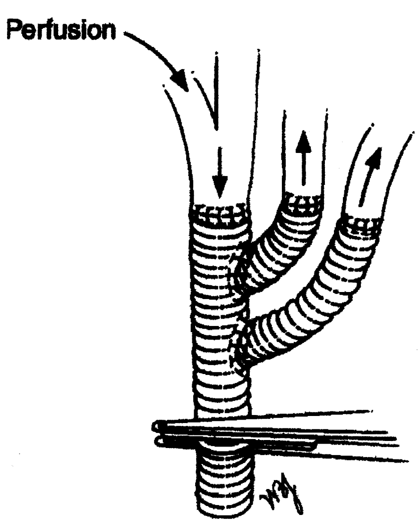

Fig 2. Selective cerebral perfusion via the right axillary artery. Left arrow = *innominate arteries;* Middle arrow = *left carotid arteries;* Right arrow = *left subclavian arteries.*

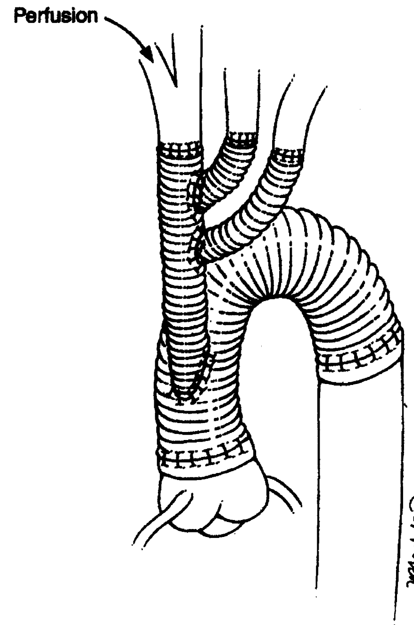

Fig 3. The arch graft is distended with cardioplegia solution to facilitate choosing the ideal site for anastomosing the trifurcated graft.

We use axillary artery cannulation, because femoral arterial perfusion, with passage of blood that is destined for the cerebral circulation through a severely atherosclerotic aorta, has been associated with strokes [2]. Perfusion through the axillary artery facilitates removal of air and allows antegrade cerebral perfusion to be resumed after the trifurcated graft is inserted.

The origins of the arch vessels are frequently involved in a diffuse atherosclerotic process. However, even in patients with severe atherosclerotic disease of the aortic arch, the arch vessels just beyond their origins are usually spared. Transecting the vessels at this level provides pliable tissue for subsequent anastomoses, helps avoid atheroembolism, and provides enormous flexibility for subsequent aortic arch reconstruction. In contrast to the branched graft technique described by Kazui and associates [3], we do not cannulate the individual arch vessels. Also, direct anastomoses to the arch vessels seem less prone to bleed but permit easy exposure for placement of extra sutures when necessary.

The trifurcated graft technique helps minimize cerebral ischemia by allowing for a period of selective antegrade cerebral perfusion, which has been shown to reduce neurologic dysfunction during circulatory arrest [4]. The trifurcated graft technique has a broad application in the repair of various aortic lesions involving the arch and is particularly well suited for "elephant trunk" reconstructions and recent modifications of that proce-

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dure [5]. Also, we think this technique will reduce neurologic and hemorrhagic complications of arch replacement.

References

1. Griepp RB, Ergin MA. Aneurysms of the aortic arch. In: Edmunds LM Jr, ed. Cardiac surgery in the adult. New York: McGraw-Hill, 1997:1197–226.
2. Westaby S, Katsumata T, Vaccari G. Arch and descending aortic aneurysms: influence of perfusion technique on neurological outcome. Eur J Cardiothorac Surg 1999;15:180–5.
3. Kazui T, Washiyama N, Muhammed BA, Terado H, Yamashita K, Takinami M. Improved results of atherosclerotic arch aneurysm operations with a refined technique. J Thorac Cardiovasc Surg 2001;121:491–9.
4. Hagl C, Ergin MA, Galla JD, et al. Neurological outcome after ascending aorta/aortic arch operations: effect of brain protection technique in high-risk patients. J Thorac Cardiovasc Surg 2001;121:1107–21.
5. Kuki S, Taniguchi K, Masai T, Endo S. A novel modification of elephant trunk technique using a single four-branched arch graft for extensive thoracic aortic aneurysm. Eur J Cardiothorac Surg 2000;18:246–8.