

## Débridement of atheroma in the proximal clamp site under hypothermic circulatory arrest for repair of abdominal aortic aneurysm with severe atherosclerosis

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Postoperative renal and other ischemic complications due to atheroembolization after clamping of the proximal site of an abdominal aortic aneurysm are catastrophic. We present here a method of débridement of atheroma and clamping under hypothermic circulatory arrest to avoid iatrogenic atheroembolization. (*J Vasc Surg Cases and Innovative Techniques* 2017;3:12-5.)

Severe atherosclerosis, so-called shaggy aorta, is a problem for cardiovascular surgeons because of its ischemic complications after clamping of the aorta. To prevent such complications, a technique without clamping is desirable. In thoracic aortic surgery, open proximal anastomosis under hypothermic circulatory arrest is widely used. In abdominal aortic aneurysm (AAA) repair, the open proximal procedure is less common because supraceliac artery clamping or the balloon occlusion method is usually used. However, we rarely encounter cases of systemic severe atherosclerosis (Fig 1) in which balloon occlusion or clamping is not ideal. This article aims to describe one of the surgical treatments of this pathologic process in which débridement of atheroma in the proximal clamp site is performed under hypothermic circulatory arrest. The patient's consent has been obtained.

### TECHNIQUE

Aortic insufficiency (AI) is confirmed by a preoperative examination. We believe that this surgery is safe for patients with less than trace AI. Patients with mild to moderate AI might not develop excessive left ventricular distention by appropriate perfusion control of extracorporeal circulation (ECC). However, patients might have difficulty in being weaned from ECC. This surgery should not be indicated for cases of more than moderate AI.

After induction of general anesthesia, transesophageal echocardiography is performed to monitor left ventricular diameter and movement. A temporary pacing catheter is inserted from the right internal jugular vein into the right

ventricle for rapid pacing and pacing in bradycardia during rewarming. Regional saturation of oxygen in the brain is monitored by the INVOS system (Covidien Japan, Tokyo, Japan), and a defibrillation pad is also attached.

Ordinary open laparotomy is performed, and the abdominal aorta is dissected for aortic clamping. After systemic heparinization (100 units/kg), the left axillary artery is exposed and anastomosed with a 7- to 9-mm prosthetic Dacron graft for arterial perfusion. Percutaneous venous drainage is performed from the right internal jugular vein (16F) and right femoral vein (24F). ECC is started with gradual systemic cooling to a bladder temperature of 28°C to avoid inducing ventricular fibrillation (VF), and left ventricular contraction and dimension are monitored. After the systemic temperature reaches 28°C, the patient is placed in the Trendelenburg position and ECC is stopped. Rapid pacing (200/min) starts and usually results in VF. If VF is induced before the predetermined temperature is reached, the diameter of the left ventricle should be noted. If the diameter does not change, ECC can continue to cool to the predetermined temperature. In case of a dilated diameter of the left ventricle, systemic flow is reduced and defibrillation should be performed. After induction of circulatory arrest, opening of the proximal anastomosis line (Fig 2, A) and removal of atheroma around the anastomosis and the clamp site (Fig 2, B-D) should be quickly performed (within 10 minutes). During circulatory arrest, the blood temperature should be warmed as high as possible in the recirculation circuit of ECC. After this procedure, ECC is gradually restarted with flushing out of debris, and proximal aortic clamping can be safely performed. This is followed by distal clamping and graft replacement. Defibrillation is performed after proximal clamping. ECC is discontinued after rewarming and confirmation of stable hemodynamics.

Graft replacement of AAA was performed in two patients with severe systemic atherosclerosis by this method. The characteristics of the patients and parameters during ECC are shown in the Table. Gradual systemic cooling to prevent induction of VF had the potential of prolonging the ECC time in both patients. In case 1, a patient whose AI was trivial, left ventricular distention was

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Author conflict of interest: none.

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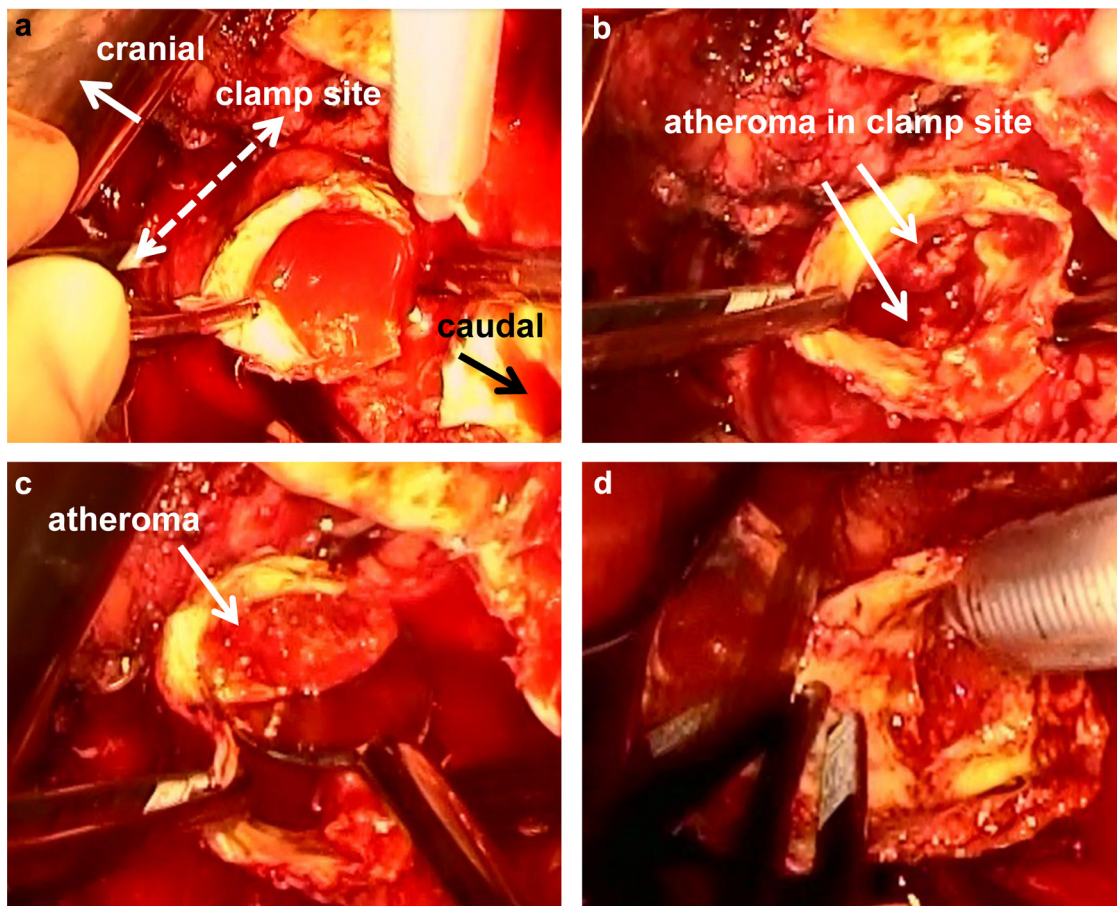
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<http://dx.doi.org/10.1016/j.jvscit.2016.10.001>



**Fig 1.** Entire aorta with severe atherosclerosis. There does not appear to be an appropriate site for clamping and balloon occlusion for repair of the abdominal aorta.



**Fig 2.** **A,** Transection of the abdominal aorta without clamping under circulatory arrest. **B,** Atheroma in the proximal clamping site. **C,** Removal of the atheroma. **D,** After débridement of the atheroma.

**Table.** Characteristics of patients and parameters during extracorporeal circulation (ECC)

	Case 1	Case 2
BSA	1.7	1.9
AI	Trace	Mild-moderate
Aneurysm type	True	True
Maximum diameter	50 mm	55 mm
Clamping site after débridement of atheroma	Infrarenal	Infrarenal
Size of Dacron graft for arterial perfusion	9 mm	9 mm
Venous cannula size (through right femoral vein)	24F	24F
Venous cannula size (through right jugular vein)	16F	16F
Cardiac rhythm when body temperature reached 28°C	VF	Sinus
Was rapid pacing required?	No	Yes
Body temperature when VF was induced	29.1°C	28°C
Was DC required for sinus conversion after reperfusion?	Yes	Yes
Blood temperature at the initiation of circulatory arrest	24.2°C	25.0°C
Blood temperature in ECC circuit at the end of circulatory arrest	30.0°C	31.7°C
Blood temperature when cardiac rhythm returned sinus conversion	30.0°C	33.7°C
Time required for body temperature to reach to 28°C	78 minutes	87 minutes
VF time	17 minutes	16 minutes
Circulatory arrest time	7 minutes	7 minutes
Total ECC time	138 minutes	112 minutes

AI, Aortic insufficiency; BSA, body surface area; DC, direct current; VF, ventricular fibrillation.

not observed from induction of VF to circulatory arrest. In case 2, mild to moderate AI was confirmed by preoperative cardiac echography. VF was not induced during cooling. However, after reperfusion, VF persisted and the diameter of the left ventricle gradually enlarged. Therefore, blood flow was diminished to 60% of normal levels with aggressive rewarming of the blood, which resulted in successful recovery of sinus rhythm.

There were no neurologic deficits in either case. The postoperative course in case 1 showed transient elevation

of serum creatinine levels 1 month after the operation. However, serum creatinine concentration returned to preoperative levels 3 months after the operation. There was no evidence of atheroembolization in case 2.

## DISCUSSION

Cross-clamping of a “shaggy aorta” during open AAA repair leads to various catastrophic thromboembolic events.<sup>1</sup> Among them, cholesterol crystal embolism has a poor prognosis and often might be fatal.<sup>2</sup> Endovascular aneurysm repair also has the potential of such risk in patients with severe atherosclerosis.<sup>3</sup> Supraceliac aorta or visceral artery clamping or balloon occlusion methods are usually used in this situation. However, we encounter patients with systemic severe atherosclerosis in whom there is no appropriate site for clamping or balloon occlusion, albeit uncommonly.

The maneuver described in this report involves débridement of an atheroma and clamping under hypothermic circulatory arrest. Vural et al reported two cases of giant-sized AAA repair using open proximal anastomosis under hypothermic arrest.<sup>4</sup> They performed median sternotomy, and standard cardiopulmonary bypass for a cardiac operation was established. The anal temperature was cooled to 18°C. Open proximal anastomosis with retrograde cerebral perfusion was performed for <40 minutes (38 and 39 minutes). Unlike in their elegant method, the permissive circulatory arrest time is limited to within 10 minutes in the present method. Circulatory arrest for 10 minutes has been reported to be safely performed when the nasopharyngeal temperature is 28°C,<sup>5</sup> and 10 minutes appears to be sufficient for only opening of the aorta and débridement around the proximal site. In cases in which not only débridement but also proximal anastomosis is attempted under circulatory arrest, the method reported by Vural et al<sup>4</sup> should be performed.

AI might be a major concern because ECC might result in excessive distention of the left ventricle in patients with considerable AI during VF. In cases of open proximal anastomosis of the distal arch through left thoracotomy under deep hypothermic arrest, sufficient venting of the left ventricle is possible from the apex of the left ventricle. However, sufficient venting of the left ventricle is difficult in this method without using median sternotomy or thoracotomy. We believe that patients with less than trace AI can safely have this surgery performed. Median sternotomy and deep hypothermic arrest are not required in our method, which might be an advantage of this procedure. In our patients described before, bicaval venous drainage was applied. Newer available femoral cannulas would be sufficient for draining the heart and enabling this surgery to become simpler.

## CONCLUSIONS

Application of hypothermic circulatory arrest using ECC for infrarenal AAA repair is not common and we do not

advocate this method. To the best of our knowledge, this method has not been reported for hypothermic circulatory arrest without opening of the chest in other abdominal vascular surgeries. Surgeons should be aware of the complications of hypothermic ECC, such as systemic inflammation, renal impairment, and stroke. This maneuver should be avoided in patients in whom ECC is strongly suspected of being associated with stroke. We should first find and clamp the healthy aorta and its branches, which is minimally invasive and can be performed in almost all cases. Therefore, this maneuver should be limited to patients in whom systemic atherosclerosis, including of the aorta and its branches, is so severe that a safe clamping or balloon occlusion site cannot be found. This maneuver might be one of the therapeutic options for preventing atheroembolization during the repair of AAA in such cases. Besides repair of AAA, this method might be useful for visceral segment thrombectomy or endarterectomy in patients with severe calcification of the aorta with difficulty in cross-clamping.

We greatly appreciate our excellent perfusionist, Naohiro Ogura, who perfectly controlled extracorporeal circulation during the operation in this study.

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Submitted Jun 16, 2016; accepted Oct 5, 2016.