Case Report

Selective Perfusion of the Upper and Lower Body under Different Levels of Hypothermia in a Patient with Coronary Artery Disease and Dissecting Thoracoabdominal Aortic Aneurysm

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Hypothermia is known to protect the myocardium and the spinal cord during ischemia. However the risk of complications increases with lower hypothermic conditions. In this paper we report a 62-year-old male patient with concomitant coronary artery disease who was surgically treated for a thoracoabdominal aortic aneurysm and an abdominal paraanastomotic pseudoaneurysm using selective perfusion of the upper and lower body under mild and deep hypothermia respectively. The patient was discharged uneventfully and only experienced transient delirium. We believe this novel modality may be a promising alternative in selected candidates. (Ann Thorac Cardiovasc Surg 2004; 10: 205–8)

Key words: aortic dissecting aneurysm, selective perfusion

Introduction

The morbidity and mortality of patients surgically treated for thoracoabdominal aortic aneurysms is related to the ischemic injury of the spinal cord, heart, kidneys, and other organs. Elective hypothermic cardiopulmonary bypass (CPB) has been successfully used for the surgical management of aneurysms and dissections of the descending thoracic and thoracoabdominal aorta, providing safe and substantial protection against paralysis, and cardiac, renal, and visceral organ failure.[1,2] In this report, we describe our surgical management of a complex case: a patient with concomitant coronary artery disease, a dissecting thoracoabdominal aortic aneurysm (DTAAA), and an abdominal paraanastomotic pseudoaneurysm (APPA). We hesitated to perform a CPB with circulatory arrest or a segmental sequential repair of the diseased aorta because there was a risk of myocardial ischemic injury considering a previous coronary artery bypass graft (CABG) and the weakness and size of the APPA. Therefore, we used selective perfusion of the upper and lower body under mild and deep hypothermia, respectively. In addition, methods of protecting the myocardium, spinal cord and abdominal viscera are discussed.

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Case Report

A 62-year-old male patient who underwent abdominal aortic aneurysm repair five years ago was admitted to our department with a diagnosis of DTAAA from the T8 level, with the intimal tear at this level (Fig. 1). The patient underwent CABG 21 months before, and concomitant APPA at the proximal site of the abdominal Y-graft was revealed then by enhanced computed tomography (CT). At the time of CABG, the right internal thoracic artery was anastomosed to the left anterior descending branch, and a saphenous vein bypass graft was anastomosed from the ascending aorta to the left circumflex branch. Postoperative follow-up CT, which showed that the diameter of the DTAAA had increased to 65 mm, extending distally and reaching the APPA of which the diameter had increased to 94 mm (Fig. 2), convinced us to perform surgery. Subsequent preoperative magnetic resonance arteriography revealed that the origin of the Adamkiewicz artery was at the L11 level. At surgery, selective bronchial intubation was performed. Both the radial arteries

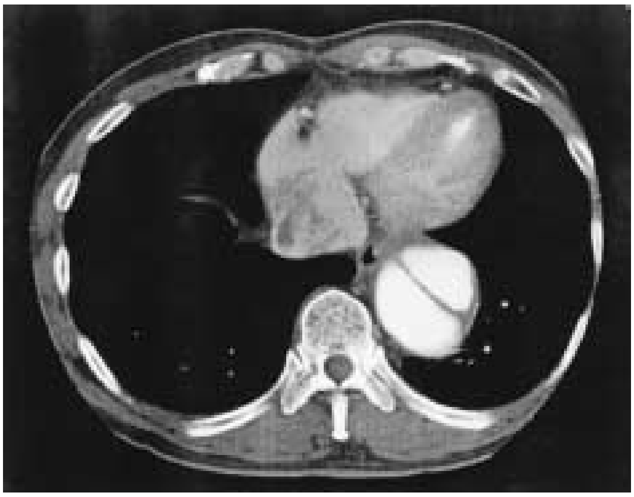

Fig. 1. Enhanced CT showing the proximal DTAAA.

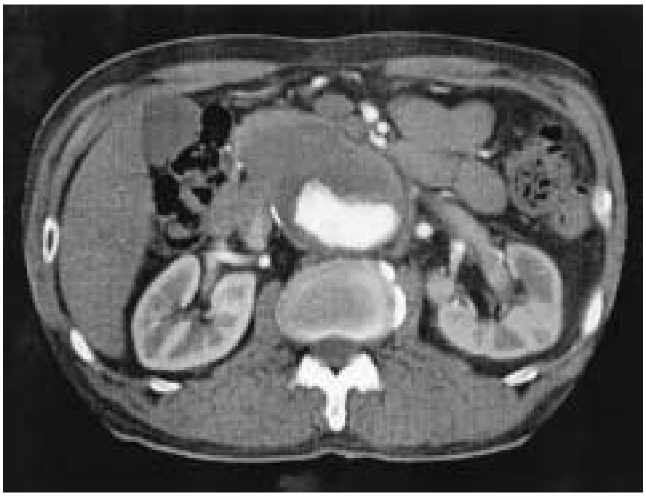

Fig. 2. Enhanced CT showing the enlarged APPA.

and the left femoral artery were cannulated for arterial pressure monitoring. Two bipolar electrodes were placed at the upper thoracic and lumbar epidural space for evoked spinal potential (ESP) monitoring to detect signs of spinal cord ischemia. Cerebrospinal fluid drainage was used as an adjunct to reduce the risk of spinal cord injury. The aortic aneurysm was exposed through a spinal thoracoabdominal incision from the sixth intercostal space. Because of the size and the wall weakness of the APPA, it was impossible to perform sequential clamping of the diseased aorta. Partial CPB was initiated from the right femoral vein to the descending thoracic aorta proximal to the dissecting aneurysm. When the body temperature reached 33°C, the aorta was clamped above the celiac artery, and the aortic aneurysm was opened distally including the APPA to the proximal part of the Y-graft. An 18 Fr. balloon catheter was introduced into the proximal site of the Y-graft and perfused at 1 L/min using an independent roller pump while the proximal descending thoracic aorta was perfused at 1.8 L/m using another pump. The upper body was mildly cooled until the esophagus was 29°C, while the lower body was cooled until the bladder reached 23°C. After opening the aneurysm, the celiac artery, superior mesenteric artery, and both renal arteries were selectively cannulated using our original multi-branched circuit[3] with balloon catheters and perfused at the same temperature as that for the lower body (Fig. 3). The aorta was replaced from the level T8 to just proximal to the Y-graft. The origin of the intercostal arteries at T8 was preserved by a beveled incision of the aortic wall. The intercostal arteries at T10, T11, the celiac artery, superior mesenteric artery, and the right renal artery were reconstructed by the graft interposition technique. The partial CPB was discontinued and the thoracoabdominal wall was closed by the standard procedure (Fig. 4). No significative changes were detected by ESP monitoring during the surgery. Pathologic examination revealed atherosclerotic degeneration. In the postoperative period, there were neither signs of spinal cord injury nor injury to other organs. The patient was extubated the next morning and oral intake was initiated on the second postoperative day. The patient did not experience any postoperative complications except for transient delirium and was discharged in good condition.

Discussion

Several authors have demonstrated that hypothermic CPB and circulatory arrest during thoracoabdominal aortic aneurysm repair allows enough time to safely perform the reattachment of intercostal, lumbar, and visceral arteries, while protecting to the heart, brain, kidney, and abdominal viscera.[4,5] However, heart fibrillation, which appears below 25°C, is not well tolerated in cases of coronary arterial disease, as in our patient, and as such constitutes a contraindication to this method.[6,7] Consequently, we performed partial CPB and perfusion of the upper body, and maintained the heart beating under mild hypothermia in order to decrease the metabolic demands of the myocardium and brain[8-11] and to improve the perfusion pressure of these organs.

Complex surgery on the thoracoabdominal aorta ex-

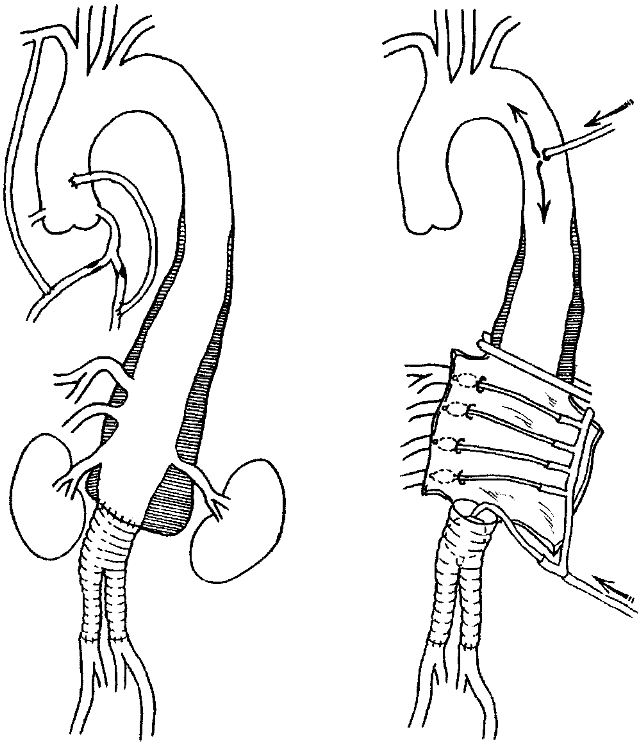

Fig. 3. Schema of the DTAAA and the APPA before the operation and after clamping and selective perfusion of the aorta and its branches.

poses patients to ischemic organ damage. It has been demonstrated that deep hypothermia provides adequate protection to the spinal cord as well as the abdominal viscera affording excellent surgical exposure.[1,5,6] Because the large and weak APPA in our patient precluded sequential repair of the distal aorta, the lower body was subjected to deep hypothermia by using a balloon catheter introduced to the proximal Y-graft. In addition, the abdominal viscera and the intercostal arteries were selectively perfused using our original multi-branched circuit device to preserve organ function and minimize ischemic time.

Additional methods of organ protection were performed on this patient. Spinal cord function was monitored intraoperatively by ESP to indicate spinal cord ischemia.[12,13] Cerebrospinal fluid drainage was also added as a protective adjunct against spinal cord ischemia.[14] Since the DTAAA and APPA were diagnosed before CABG, we did not use the left internal thoracic artery to maintain collateral blood flow to the spinal cord so as not to reduce this flow during DTAAA repair.

In conclusion, we have successfully treated a patient with coronary artery disease and a dissecting thoracoabdominal aortic aneurysm using a combined strategy. The upper body was selectively perfused under mild hypothermia, maintaining the beating heart, while the spinal cord, abdominal viscera, and lower body were perfused under deep hypothermia. Although our patient developed no postoperative complications, further evaluations including a randomized study of patients, are warranted to validate this technique.

Fig. 4. Postoperative three-dimensional CT showing good patency of the replaced thoracoabdominal aorta and its branches.

References

1. Kouchoukos NT, Masetti P, Rokkas CK, Murphy SF. Hypothermic cardiopulmonary bypass and circulatory arrest for operations on the descending thoracic and thoracoabdominal aorta. *Ann Thorac Surg* 2002; **74**: S1885–7.
2. Frank SM, Parker SD, Rock P, et al. Moderate hypothermia with partial bypass and segmental sequential repair for thoracoabdominal aortic aneurysm. *J Vasc Surg* 1994; **19**: 687–97.
3. Shiiya N, Kunihara T, Yamauchi H, et al. Use of selective visceral shunting during operation for thoracoabdominal aortic aneurysm: clinical assessment

of organ protection. *Jpn J Artif Organs* 1999; **28**: 100–3. (in Japanese)

4. Crawford ES, Coselli JS, Safi HJ. Partial cardiopulmonary bypass, hypothermic circulatory arrest, and posterolateral exposure for thoracic aortic aneurysm operation. *J Thorac Cardiovasc Surg* 1987; **94**: 824–7.
5. Kouchoukos NT, Wareing TH, Izumoto H, Klausing W, Abboud N. Elective hypothermic cardiopulmonary bypass and circulatory arrest for spinal cord protection during operations on the thoracoabdominal aorta. *J Thoracic Cardiovasc Surg* 1990; **99**: 659–64.
6. Okita Y, Takamoto S, Ando M, et al. Repair for aneurysms of the entire descending thoracic aorta or thoracoabdominal aorta using a deep hypothermia. *Eur J Cardiothorac Surg* 1997; **12**: 120–6.
7. von Segesser LK, Marty B, Mueller X, et al. Active cooling during open repair of thoraco-abdominal aortic aneurysms improves outcome. *Eur J Cardiothorac Surg* 2001; **19**: 411–6.
8. Ning XH, Xu CS, Song YC, et al. Hypothermia preserves function and signaling for mitochondrial biogenesis during subsequent ischemia. *Am J Physiol* 1998; **274**: H786–93.
9. Jacobs MJ, de Mol BA, Veldman DJ. Aortic arch and proximal supraaortic arterial repair under continuous antegrade cerebral perfusion and moderate hypothermia. *Cardiovasc Surg* 2001; **9**: 396–402.
10. Tabayashi K, Akimoto K, Niibori K, Iguchi A, Ohmi M, Mohri H. Separate perfusion of upper and lower body for ruptured thoracoabdominal aortic aneurysm: a case report. *Nippon Kyobu Geka Gakkai Zasshi* 1992; **40**: 570–3. (in Japanese)
11. Ohmi M, Ito T, Niibori K, et al. Separate perfusion of upper and lower body under mild hypothermia during operation on the throacoabdominal aorta. *Kyobu Geka* 1995; **48**: 725–31. (in Japanese)
12. Shiiya N, Yasuda K, Matsui Y, Sakuma M, Sasaki S. Spinal cord protection during thoracoabdominal aortic aneurysm repair: results of selective reconstruction of the critical segmental arteries guided by evoked spinal cord potential monitoring. *J Vasc Surg* 1995; **21**: 970–5.
13. Matsui Y, Goh K, Shiiya N, et al. Clinical application of evoked spinal cord potentials elicited by direct stimulation of the cord during temporary occlusion of the thoracic aorta. *J Thorac Cardiovasc Surg* 1994; **107**: 1519–27.
14. Coselli JS, LeMarie SA, Koksoy C, Schmittling ZC, Curling PE. Cerebrospinal fluid drainage reduces paraplegia after thoracoabdominal aortic aneurysm repair: results of a randomized clinical trial. *J Vasc Surg* 2002; **35**: 631–9.