Early patency rate and fate of reattached intercostal arteries after repair of thoracoabdominal aortic aneurysms

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Objectives: The present study analyzes the early patency of intercostal artery reconstruction, using graft interposition and aortic patch anastomosis, and determines the fate of reattached intercostal arteries after repair of thoracoabdominal aortic aneurysms.

Methods: We selected 115 patients (mean age, 63 ± 15 years; range, 19-83 years; male, n = 83) treated by thoracoabdominal aortic aneurysm repair with 1 or more reconstructed intercostal arteries at the Kobe University Graduate School of Medicine between October 1999 and December 2012. The intercostal arteries were reconstructed using graft interposition (n = 66), aortic patch anastomosis (n = 42), or both (n = 7).

Results: The hospital mortality rate was 7.8% (n = 9). Eleven patients (9.6%) developed spinal cord ischemic injury (permanent, n = 6, transient, n = 5). The average number of reconstructed intercostal arteries per patient was 3.0 ± 1.5 (1-7), and 345 intercostal arteries were reattached. The overall patency rate was 74.2% (256/345) and that of aortic patch anastomosis was significantly better than that of graft interposition (90.8% [109/120] vs 65.3% [147/225], $P < .01$), but significantly worse for patients with than without spinal cord ischemic injury (51.9% [14/27] vs 76.1% [242/318], $P = .01$). There was no patch aneurysm in graft interposition during a mean of 49 ± 38 (range, 2-147) postoperative months, but aortic patch anastomosis including 4 intercostal arteries became dilated in 2 patients.

Conclusions: Aortic patch anastomosis might offer better patency rates and prevent spinal cord ischemic injury compared with graft interposition. Although aneurysmal changes in intercostal artery reconstructions are rare, large blocks of aortic wall reconstruction should be closely monitored. (J Thorac Cardiovasc Surg 2014;147:1861-7)

ACD

Thoracoabdominal aortic aneurysm (TAAA) repair is a highly invasive procedure with 30-day mortality rates ranging from 7.0% to 10.0% even at centers with high surgical volumes,[1-3] and spinal cord ischemic injury (SCII) remains one of the most serious complications, occurring at an incidence of 3% to 5%.[1-3] Despite advances during the past 2 decades, a reliable method of preventing SCII has not been established. Multidisciplinary approaches are important for the safe repair of TAAA, and revascularization of the intercostal arteries (ICAs) represents an important technical step. Despite much individual diversity, the spinal cord is usually supplied with blood from branches of the vertebral, internal iliac, and ICAs. Many surgeons have attempted to reattach ICAs during TAAA repair based on anatomic blood feeds. However, little is known about the patency rates of reattached ICAs and the clinical association with SCII. Some authors think that ICA reattachment might be unnecessary because various collateral networks, such as branches of the subclavian or internal iliac arteries, also supply blood to the spinal cord.[4] Late complications of reattached ICAs include the development of aneurysm.[5] The clinical validity of ICA reattachment remains controversial. We aggressively reattach ICAs to maintain the blood supply to the spinal cord during TAAA repair at Kobe University Graduate School of Medicine. We investigated the patency rate, the relationship between the patency of reconstructed ICAs and SCII, and the fate of reattachment aortic intercostal patch during follow-up.

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MATERIALS AND METHODS

All patients had previously granted permission for use of their medical records regarding information about preoperative status, surgery performed, postoperative course, medical examinations, and late follow-up for medical purposes. Patient safety and privacy were strictly managed in keeping the medical records. The institutional review board at Kobe University Graduate School of Medicine approved this retrospective observational review of the data collected for this study. Among 158 patients who underwent TAAA repair between October 1999 and December 2012 at the Kobe University Graduate School of Medicine, 131 required 1 or more ICA reconstructions. Of these, 1 patient with Crawford extent IV and 15 patients in whom reconstructed ICA patency could not be postoperatively evaluated by angiography or computed tomography (CT) (n = 15) were excluded from the analysis. We finally analyzed data derived from 115 patients (male, n = 83 [72.2%]; mean age, 63 ± 15 [range, 19-83] years). We classified TAAA as Crawford extent I (n = 19), II (n = 40), and III (n = 56), and

Abbreviations and Acronyms

AKA = Adamkiewicz artery
CSF = cerebrospinal fluid
CT = computed tomography
ICA = intercostal artery
SCII = spinal cord ischemic injury
TAAA = thoracoabdominal aortic aneurysm

21 patients had Marfan syndrome. A history of aortic surgery was defined as previous surgery to treat a descending thoracic or abdominal aortic aneurysm. Chronic renal failure was defined as serum creatinine 2.0 mg/dL or greater. Chronic obstructive pulmonary disease was defined as forced expiratory volume in 1 second less than 75% of the value predicted by spirometry. We preoperatively confirmed that 85 patients had an Adamkiewicz artery (AKA) by CT or magnetic resonance imaging angiography. Table 1 shows the preoperative characteristics of the patients.

Surgical Technique

The details of our technique for TAAA repair have been reported.[6] We usually placed a cerebrospinal fluid (CSF) drainage catheter into the subarachnoid space on the day before the surgery. For various reasons, such as emergency surgery, hemodynamic instability, coagulopathy, anatomic reasons, and drainage catheter occlusion, CSF drainage was accomplished in 82.6% of patients (95/115). The CSF was allowed to freely drain whenever CSF pressure exceeded 10 mm Hg. Transcranial motor-evoked potentials were applied to monitor spinal cord ischemia during the procedure. The patients were intubated with a double-lumen endotracheal tube to allow the left lung to collapse. Heparin was administered to achieve an activated clotting time of greater than 400 seconds. Cardiopulmonary bypass was established via cannulation of the left femoral artery and the right femoral vein, and if necessary, the pulmonary artery was also cannulated for venous drainage. The pump circuit had an extracorporeal membrane oxygenator including a heat exchanger. Body temperature was usually set to between 31°C and 34°C (rectal temperature, n = 78). Deep hypothermia and circulatory arrest were applied if crossclamping of the proximal aorta seemed impossible (n = 37). The aorta was anastomosed to a gelatin-impregnated woven Dacron graft. The aorta was sequentially clamped, and patent intercostal and lumbar arteries at the Th8 to L2 level were reimplanted by graft interposition or aortic patch anastomosis (Figure 1) and immediately reperfused. Graft interposition means that patent orifices of ICAs are reattached through a short graft (8 or 10 mm) with an end-to-side anastomosis. Aortic patch anastomosis means that patent orifices of ICAs are anastomosed to a side hole on the graft as an aortic cuff using an inclusion technique. Significant back-bleeding from ICAs was controlled by inserting balloon catheters or by externally clamping the ICAs to alleviate the steal effect from the anterior spinal artery. Our intraoperative decision-making regarding which ICAs to reattach was based on the following findings. If an AKA was included in the range of graft replacement, we always tried to reconstruct the ICA that was considered as a donor to the AKA. In addition to AKA reconstruction, among the ICAs from Th8 to L2, we generally select ICAs for reattachment that have large orifices or those in which back-bleeding from the orifice is significant. If the amplitude of transcranial motor-evoked potentials declined, the ICA and lumbar artery were reattached as soon as possible. Mean distal perfusion pressure was always maintained at greater than 70 mm Hg. Visceral arteries were routinely perfused by selective cannulation using a separate roller pump to reattach the visceral arteries. Blood flow in each visceral branch was controlled at 150 mL/min. The visceral and renal arteries were separately reconstructed as much as possible to reduce the area of the aneurysmal wall.

Data Definitions

We defined SCII as any new lower-extremity motor or sensory deficit, or as both in the absence of any documented intracerebral hemispheric events. Patients who were fully ambulatory before surgery had to be able to bear

TABLE 1. Preoperative profiles of patients

Variable	Overall (%)	Graft interposition (%)	Aortic patch anastomosis (%)	Both methods (%)	*P* value*
Patients	115	66	42	7	
Age (mean ± SD)	63 ± 15	62 ± 16	63 ± 14	65 ± 12	.89
Male gender	83 (72.2)	48 (72.7)	31 (73.8)	4 (57.1)	.90
Aortic disease					
Nondissection	53	32 (48.5)	19 (45.2)	2 (28.6)	.93
Dissection	62	34 (51.5)	23 (54.8)	5 (71.4)	.74
Crawford extent (I/II/III)	19/40/56	14/19/33	5/19/18	0/2/5	
% Crawford extent II	34.8	28.8	45.2	28.6	.08
Marfan syndrome	21 (18.3)	11 (17.5)	8 (19.0)	2 (28.6)	.95
History of aortic surgery	27 (23.5)	14 (21.2)	10 (23.8)	3 (42.9)	.75
Emergency/urgent surgery	15 (13.0)	11 (16.7)	4 (9.5)	0	.45
Smoking history	65 (56.5)	33 (50.0)	28 (66.7)	4 (57.1)	.09
Hypertension	93 (80.9)	51 (77.3)	35 (83.3)	6 (85.7)	.60
Diabetes mellitus	13 (11.3)	6 (9.1)	5 (11.9)	1 (14.3)	.88
Hyperlipidemia	26 (22.6)	12 (18.2)	11 (26.2)	2 (28.6)	.32
Chronic renal failure (sCr ≥2.0)	12 (10.4)	7 (10.6)	4 (9.5)	1 (14.3)	.88
Chronic obstructive pulmonary disease	10 (8.7)	5 (7.6)	5 (11.9)	0	
Permanent hemodialysis	6 (5.2)	3 (4.5)	3 (7.1)	0	.89
CSF drainage	95 (82.6)	52 (78.8)	36 (85.7)	7 (100)	.52
Preoperative AKA detection	85 (73.9)	44 (66.7)	34 (81.0)	7 (100)	.16
Timing of surgery					
1999-2006	53 (46.1)	50 (75.8)	3 (7.1)	0	<.01
2007-2012	62 (53.9)	16 (24.2)	39 (92.9)	7 (100)	<.01

AKA, Adamkiewicz artery; *CSF*, cerebrospinal fluid; *sCr*, serum creatinine; *SD*, standard deviation. **P* value means graft interposition versus aortic patch anastomosis.