Original Article

Paraplegia and Paraparesis after Descending Thoracic Aortic Aneurysm Repair: A Risk Factor Analysis

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Background: The risk factors of paraplegia and paraparesis (P/P) after surgical repair of descending thoracic aortic aneurysm (TAA) are controversial.

Patients and Methods: Seventy five patients underwent surgical repair of descending TAA from 2001 through 2002. The mean age was 64.2±5.2 years old (range; 26-81) and 58 patients (77.3%) are male. There were 47 patients (62.7%) with nondissecting aortic aneurysm and 28 patients (37.3%) with chronic dissecting aortic aneurysm. Emergent operation was performed in 13 cases (17.3%). Retrospective analysis based on data of these 75 patients was performed to determine the risk factors of P/P.

Results: 30-days hospital mortality was 2.7%. The overall incidence of P/P was 12.0% (9/75) overall (immediate paraplegia; 4 (5.3%), delayed paraplegia; 1 (1.3%), immediate paraparesis; 3 (4.0%), delayed paraparesis; 1 (1.3%)). Logistic regression analysis revealed that predictive factors of the development of P/P were; cases in which the distal part (below Th9) of the descending thoracic aorta was included in the extent of graft replacement (P=0.020; odds ratio (OR), 7.981) and nondissecting aneurysm (P=0.029; OR, 12.109).

Conclusion: There was an increased risk of P/P after descending TAA repair in cases in which the extent of graft replacement included below the Th9 or in cases with nondissecting aortic aneurysm. (Ann Thorac Cardiovasc Surg 2006; 12: 179–83)

Key words: paraplegia, paraparesis, descending thoracic and thoracoabdominal aortic aneurysm

Introduction

Paraplegia and paraparesis (P/P) resulting from spinal cord ischemic damage remains the most devastating complication after descending thoracic and thoracoabdominal aortic aneurysm (TAAA) repair. Recent recommendations regarding such aneurysm management have emphasized individualized treatment based on balancing a patient's calculated risk of postoperative death or P/P.[1] However, the risk factors of P/P after descending thoracic aortic aneurysm (TAA) and TAAA repair are still controversial.[2-4] The purpose of this study was to determine which perioperative factors currently predict P/P after repair of descending TAA.

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Patients and Methods

Between January, 2001, and December, 2002, 75 patients with descending TAA were surgically treated in Osaka University Hospital and its 11 associated hospitals. Patients' age ranged from 26 to 81 years (mean 64.2±5.2 years). Fifty eight patients (77.3%) were male. The type of aneurysm consisted of chronic dissecting aneurysm (n=28, 37.3%) and nondissecting aneurysm (n=47, 62.7%). Acute dissecting aneurysm, defined as having been operated on within 14 days of onset, was not present in this series. In order to classify the extent of graft re-

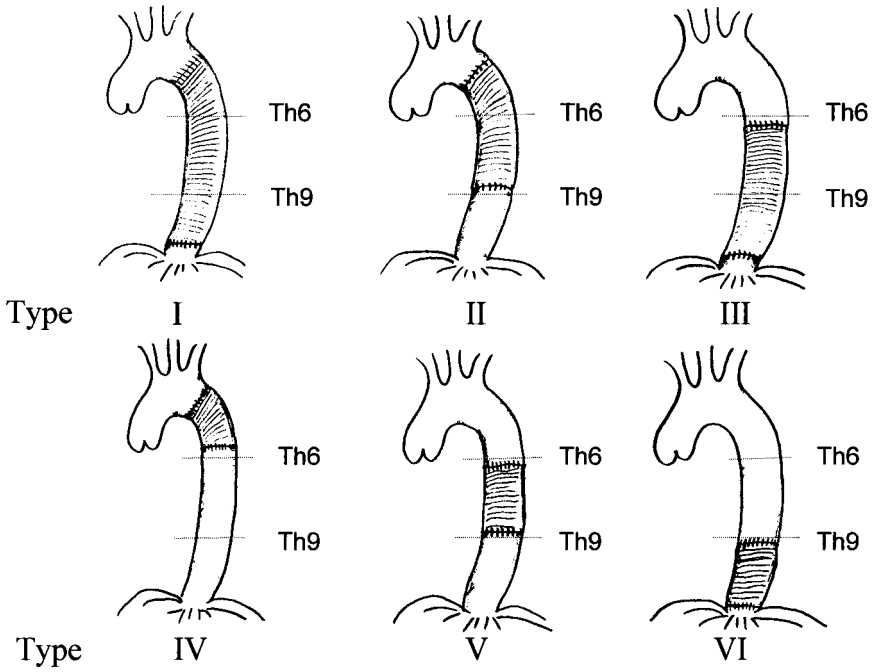

Fig. 1. The classification of the extent of graft replacement.
The descending thoracic aorta was divided into three parts. The proximal part ranges from the distal part of the left subclavian artery to Th6, the medial part from Th7 to Th8 and the distal part below Th9 to diaphragm level. The extent of graft replacement was classified into 6 types; the whole type (type I), the proximal and medial part (type II), the medial and distal part (type III), the proximal part (type IV), the medial part (type V) and the distal part (type VI).

placement performed, the descending thoracic aorta was divided into three parts. The proximal part ranges from the just distal of the left subclavian artery to Th6, medial part from Th7 to Th8 and distal part below Th9 to diaphragm level. The extent of graft replacement was classified into 6 types (Fig. 1); the whole type (type I; 28 patients), the proximal and medial part (type II; 19 patients), the medial and distal part (type III; 7 patients), the proximal part (type IV: 9 patients), the medial part (type V: 4 patients) and distal part (type VI: 8 patients) (Table 1). Emergent operation was performed in 13 cases (17.3%).

Regarding spinal cord protection, reattachment of patent segmental intercostal and lumbar arteries in the T9 to L1 region was performed whenever possible. Intercostal arteries in the region from T4 to T8 were ligated. Cerebrospinal fluid drainage, intravenous naloxone, and somatosensory or motor evoked potential monitoring were not routinely used but used based on surgeon's preference or patient's general condition. In all patients, intravenous heparin (300 U/kg) was administered before aortic clamping. Femorofemoral partial bypass (FFB) or total cardiopulmonary bypass (CPB) was selectively used in 74 patients (98.7%). Neither FFB or CPB were applied in one patient (1.3%) due to complete obstruction of the infrarenal aorta. All patients underwent graft replacement.

All patients received careful preoperative neurological examinations with documentation of lower extremity motor function. Formal evaluation by a neurologist was obtained in all patients in whom any neurological deficit was identified. P/P included both immediate and delayed deficits. Unilateral deficits, unless associated with an ipsilateral upper limb deficit (i.e., stroke), were also included in the P/P group.

The followings 9 parameters were examined as possible risk factors affecting the development of P/P: 1) age (years) 70> or 70≦; 2) gender; 3) the extent of graft replacement including distal part (type I, III, IV); 4) including more than 2 segments (type I, II, III); 5) dissecting or nondissecting aneurysm; 6) emergent operation; 7) application of spinal drainage; 8) intercostal reconstruction and 9) segmental repair.

Statistical analysis

Statistical analysis was done on the SPSS, version 11.0J (SPSS Inc., Chicaco, IL, USA). Data for groups were summarized as mean±SD or as a percent. Difference between groups was tested for statistical significance with an unpaired t test or Chi-square test. The predictive factors affecting the development of P/P were determined by backward stepwise logistic regression analysis. A P value less than 0.05 was considered significant.

Table 1. Incidence of paraplegia and paraparesis (P/P) after repair of the descending thoracic aorta

Extent	No. of patients	P/P		Total
		Paraplegia	Paraparesis	
I	28 (37.3%)	4 (14.3%)	1 (3.6%)	5 (17.9%)
II	19 (25.3%)	0	1 (5.3%)	1 (5.3%)
III	7 (9.3%)	0	0	0
IV	9 (12.0%)	1 (11.1%)	0	1 (11.1%)
V	4 (5.3%)	0	0	0
VI	8 (10.7%)	0	2 (25.0%)	2 (25.0%)
Total	75	5 (6.7%)	4 (5.3%)	9 (12.0%)

Table 2. Univariate and multivariate analysis for paraplegia and paraparesis (P/P) in all 75 patients

	n	P/P (%)	Univariate	Multivariate	OR
Preoperative factors					
Age (years)					
70≦age	38	15.7	P=0.4799		
70>age	37	8.1			
Gender					
Male	57	14.0	P=0.6779		
Female	18	5.5			
The extent of graft replacement including distal part (below T9)					
Yes	40	17.5	P=0.1708	P=0.020	7.981
No	33	6.1			
Extent (more than 2 segments)					
Yes (type I, II, III)	24	25.0	P=0.0513		
No (type IV, V, VI)	49	6.1			
Non dissecting					
Yes	47	19.1	P=0.0223	P=0.029	12.109
No	28	0.0			
Urgency					
No emergency	62	12.9	P=0.9501		
Emergency	13	7.6			
Intraoperative factors					
Spinal drainage					
Yes	20	5.0	P=0.4299		
No	55	14.5			
Intercoastal reconstruction					
Yes	10	0.0	P=0.5981		
No	65	13.8			
Segmental repair					
Yes	8	0.0	P=0.5911		
No	67	13.4			

OR, odds ratio.

Results

The overall 30-day mortality and in-hospital mortality rate was 2.7% (2/75 patients) and 8.0% (6/75 patients), respectively. The overall incidence of P/P was 12.0% (9/75 patients) with paraplegia, 5 of 75 (6.7%; immediate 4, delayed 1) and paraparesis, 4 of 75 (5.3%; immediate 3, delayed 1). P/P occurred only in patients with nondissecting aneurysm. The incidence of P/P by aneurysm extent was 5 out of 28 (17.9%) in type I, 1 out of 19 (5.3%) in type II, 1 out of 9 (11.1%) in type IV and 2 out of 8 (25%) in type VI (Table 1). On univariate analysis between P/P and no P/P group, nondissecting aneurysm (P=0.022) were significant preoperative variables (Table 2). On multivari-

ate analysis, nondissecting (P=0.029; odds ratio (OR), 12.109) or the case in which the extent of the graft replacement included the distal part (below Th9) were also preoperative predictive factors of spinal cord dysfunction (Table 2).

Discussion

P/P after operation on the thoracic aorta is a disastrous and unpredictable complication. The reported prevalence of paraplegia ranges from 2.3% to 23% in operations on the thoracic aorta.[5] Because of high morbidity and mortality regarding the management of such an aneurysm, recent recommendations have emphasized individualized treatment based on balancing a patient's calculated risk of postoperative death or paraplegia.[1] As for paraplegia, various methods of spinal cord protection have been suggested,[6-8] including temporary shunts, partial bypass, cerebrospinal fluid drainage and systemic or regional hypothermia. However, the application of each adjunct has been somewhat unclear. Therefore it is necessary to clear the risk factors in each kind of aneurysm. With regard to TAAA, Coselli et al. reported that extent II and diabetes were risk factors of development of P/P.[2] However, there have been few reports regarding the risk factors of P/P after TAA repair.[4,9]

The present study demonstrated that the incidence of P/P after chronic nondissecting descending TAA repair was significantly higher compared to that after chronic dissecting aneurysm repair (P=0.022) on a Chi-square test and nondissecting descending TAA was a significant risk factor of the development of P/P on multivariate analysis. The information of the relationship between a nondissecting aneurysm and P/P after descending TAA repair is limited. In contrast, the relationship between dissection and P/P after TAAA repair has been well discussed in the literature. In the 1994 report on Crawford's TAAA experience by Svensson et al.,[10] dissection was associated with P/P in the 1,509 patients on univariate analysis only. On the other hand, Cox et al.[11] found no difference in a review of 129 patients with TAAA repairs performed between 1966 and 1991. In the 1997 report on Coselli's TAAA experience after thoracoabdominal aortic aneurysm repair in 660 patients, the risk of P/P was 5.5% (27/493) for those without dissection and 5.0% (8/159) for those with dissection (P=not significant).[3] They also reported the risk of P/P for acute versus chronic dissection was 19% versus 2.9% (P=0.011), respectively and chronic dissection does not increase the risk of postoperative P/P. Without univariate and multivariate analysis performed, the incidence of P/P for those with chronic dissection tends to be lower than those without dissection (2.9% versus 5.5%). Patients with a chronic nondissecting aneurysm generally tend to have more mural atherosclerotic debris.[12-14] This fact has several characteristics that contribute to a higher risk of P/P for patients with a nondissecting descending TAA. First, with much debris present in the aortic lumen, from which the intercostal arteries generally arise, the risk of embolization into these vessels is more likely. Second, in nondissecting TAA, aortic mural atherosclerotic disease often results in chronic stenosis or occlusion of many intercostal arteries. This fact makes spinal cord arterial circulation dependent on more tenuous collateral circulation.[13] Therefore, although spinal cord ischemic time usually ends when the clamp is placed distal to patent reattached intercostal arteries, spinal cord ischemia continues until distal blood flow is reestablished in patients in whom the blood supply is dependent on distal collateral blood flow.

This present study classified the extent of graft replacement in six types in order to examine the relationship between the location and the extent of graft replacement and the development of P/P. Repair of descending TAA including the distal part (below Th9) increases postoperative P/P on multivariate analysis. This result might be affected by the fact that around 70% of the critical middle thoracic spinal cord feeding artery (Adamkiewicz artery) arises from the Th9 to Th12.[15,16]

The present study has several important limitations. The total amount of cases was relatively small and the present series was analyzed retrospectively. Because of the multi center study, the operative procedure and spinal cord protection were dependent on each institute preference. Though spinal cord protection such as spinal drainage, intercostal reattachment and segmental reattachment have been considered to lower the rate of the development of P/P, few prospective and randomized clinical studies have been performed and the efficacy of such adjuncts is still controversial.[17-19] The present study could not demonstrate the significantly effective spinal cord protection, which might be due to these limitations. Further prospective and randomized clinical studies are necessary to determine more credible predictive factors of development of P/P and significantly effective spinal cord protection after surgical repair of the descending TAA.

The present study revealed that the case in which the extent of graft replacement included distal part (below Th9) of the descending thoracic aorta or nondissecting

aneurysm were predictive factors of the development of P/P after surgical repair of the descending TAA. On repair of such a type of aneurysm, more aggressive application of spinal cord protection such as spinal drainage or epidural cooling[5] might be proposed because of its potential high risk of development of P/P.

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