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Operative Results and Clinical Features of Chronic Stanford Type B Aortic Dissection: Examination of 234 Patients Over 6 Years

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WHAT THIS PAPER ADDS

By analyzing the characteristics of the false lumen in open operated cases, this article reconsiders the usefulness of open surgery for chronic dissection, and shows improving operative results.

Objective/background: Recently, the indications for thoracic endovascular aortic repair (TEVAR) have been expanding, and the applicability of TEVAR for acute type B aortic dissection (TBAD) is proposed with regard to the high mortality of open surgery for chronic TBAD. TEVAR in the acute phase may lead to remodeling of the false lumen (FL), but it is controversial whether it completely resolves the aortic expansion in the chronic phase. In this study, operative results and the relationship between FL status and the time before surgical intervention were retrospectively analyzed.

Methods: From January 2008 to September 2013, 234 patients underwent open surgery for chronic TBAD. Most patients were on left heart bypass. By considering Japanese aortic disease treatment guidelines and the smaller physique of Japanese patients, operative indications were aneurysm >50 mm in diameter or rapid aneurysm enlargement of >5 mm in a 6 month period.

Results: In 180 cases, the FL was patent. The mean interval between onset of TBAD and operation was 61 $\pm$ 54 months. There was no significant difference between patients in the patent FL group and those in the thrombosed FL group ($p = .44$). Mean ratio of FL diameter to maximum aortic diameter (FL/AD) was 0.64 $\pm$ 0.21. There was no correlation between FL and AD before the operation ($r = .12$). Descending thoracic aortic replacement (DTAR) was performed in 127 cases and thoracic ascending aortic replacement (TAAR) in 107 cases (Crawford type I, $n = 9$; Crawford type II, $n = 65$; Crawford type III and IV, $n = 22$, respectively; Safi type V, $n = 11$). The overall operative mortality was 6.8%: 3.9% (5/127) for DTAR and 10.3% (11/107) for TAAR. The three year survival was 86.7, and the freedom from re-intervention rate was 97.0%.

Conclusion: Enlargement of uncomplicated TBAD in the chronic phase was poorly related to FL status and the results of open repair have improved. However, further prospective study is necessary.

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Keywords: Chronic dissection, Descending aorta thoraco-abdominal aorta, Open surgery, Stanford type B

INTRODUCTION

Recent advances in thoracic endovascular aortic repair (TEVAR) have led to an expansion of indications for surgery for acute type B aortic dissection (TBAD). Multiple studies have found that for complicated acute cases of TBAD accompanied by organ malperfusion, TEVAR is associated with favorable outcomes.[1,2] The usefulness of TEVAR for uncomplicated acute TBAD has also been reported with high mortality and morbidity of open surgery for expanded chronic TBAD. TEVAR in the acute phase may lead to remodeling of false aortic lumen (FL), that is, progressive reduction in diameter, and thrombosis of the FL. It does not mean that TEVAR in the acute phase completely resolves the aortic expansion in the chronic phase.

Open surgery for chronic TBAD is associated with relatively high mortality and morbidity rates,[3] and the importance of early intervention for uncomplicated TBAD has been emphasized by some studies.[4,5] However optimized medical treatment with antihypertensive agents and rest has a long history and is still the gold standard.[6]

At the authors' institution, the basic strategy for uncomplicated TBAD is conservative treatment in the acute phase and open surgery in the chronic phase if patients

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present with aneurysmal changes, and operative results have improved.

The objective of current study was to clarify whether FL status (diameter and thrombosis) has any relationship with the duration of critical expansion, and to examine whether open surgery in the chronic phase is a valid treatment option.

MATERIALS AND METHODS

Patient population

Between January 2008 and September 2013, 621 patients underwent descending thoracic and thoraco-abdominal aortic replacement (DTAR and TAAR, respectively). Of these patients, 234 had chronic Stanford type B aortic dissections. At the authors' institution, patients meeting the indication for surgery are allowed to opt for it. For this reason, patients were rarely refused surgery. In the same period, only 49 cases of TEVAR were preformed; one case was for acute TBAD, and two cases were for chronic TBAD.

The indication for DTAR or TAAR was an overall aortic diameter of >50 mm, rapid enlargement of >5 mm within 6 months, infection, or rupture. This is based on Japanese aortic disease treatment guidelines, which recommend surgery for rapidly enlarging aneurysms that dilate >5 mm in 6 months, and the authors' experience that 90% of ruptured or impending ruptured descending thoracic and thoraco-abdominal aneurysms were >50 mm. Prior to surgery, patients underwent computed tomography (CT) annually until the maximum aortic diameter exceeded 50 mm. After surgery, CT was performed at 3, 6, and 12 months and annually thereafter.

The pre-operative characteristics of the patients are described in Table 1. Pre-operative FL status was assessed by pre-operative enhanced CT. Patent FL was defined as the absence of thrombi in the FL. FL thrombosis was defined as the absence of contrast in the FL on CT, and partial lumen thrombosis was defined as the presence of both thrombosis and contrast in the FL. FL patency was assessed by venous phase CT angiography if possible. In three cases, enhanced CT scans were not performed.

Table 1. Pre-operative characteristics.

	All patients (n = 234)	DTA (n = 127)	TAAA (n = 107)	p
Mean ± SD age (y)	60.4 ± 13.0	60.5	59.5	.57
Male	187 (79.9)	108 (85.0)	79 (73.8)	.03
Coronary arterial disease	45 (19.2)	23 (18.1)	18 (16.8)	.53
Chronic lung disease	46 (19.7)	32 (25.2)	14 (13.1)	.02
Smoking	126 (53.8)	74 (58.3)	52 (48.6)	.16
Diabetes	16 (6.8)	11 (8.7)	5 (4.7)	.22
Chronic renal insufficiency	16 (6.8)	7 (5.5)	9 (8.4)	.38
Hemodialysis	10 (4.3)	4 (3.1)	6 (5.6)	.35
Emergent or urgent operation	18 (7.7)	8 (6.3)	10 (9.3)	.38
Mean ± SD maximum diameter (mm)	58.4 ± 10.7	57.5	59.6	.14

Note. Data are n (%) unless otherwise indicated. DTA = Descending thoracic aneurysm; TAAA = Thoraco-abdominal aortic aneurysm.

To calculate the FL/aortic diameter (AD) ratio, the largest axial aortic diameter image was used. True lumen and FL were determined by evaluating continuity with the normal aorta lumen.

Study variables

Regarding the pre-operative variables, chronic renal failure as the indication for dialysis and chronic renal insufficiency were defined as a serum creatinine level >2.0 mg/dL.

All operations were performed >30 days after the onset of aortic dissection, based on Japanese guidelines (Guidelines for Diagnosis and Treatment of Aortic Aneurysm and Aortic Dissection) that define the period within 2 weeks as the acute phase, and the period after the acute phase as the chronic phase. The maximum aortic diameter was based on measurements of all segments of the descending thoracic, thoraco-abdominal and abdominal aorta, and the largest diameter was used as the maximum diameter.

Operative death was defined as death within 30 days of surgery. Post-operative acute renal dysfunction was defined as the need for temporary dialysis during the post-operative period. Spinal cord deficits were defined as deficits present at discharge and were further classified according to severity as follows: permanent paraplegia (unable to move legs) and paraparesis (partial paralysis of the lower limbs). Pulmonary complications included atelectasis necessitating non-invasive positive pressure ventilation; pleural effusion requiring drainage; pneumonia; pneumothorax; prolonged ventilation (>48 h); chylothorax; and tracheostomy. When the incidence of complications was calculated, multiple events (e.g., atelectasis and tracheostomy) within the same category were treated as a single occurrence.

To better assess the overall incidence of major complications, major adverse outcomes were defined as: in hospital death (including operative death), spinal cord ischaemia, severe stroke, the need for *de novo* dialysis at discharge, and tracheostomy.

Operative procedure

The basic strategy was left heart bypass (LHB). The LHB circuit included an in line centrifugal pump with a heat exchanger. For this purpose, cannulae were placed in the left atrium for outflow and the left common femoral artery for inflow. Spinal drainage was not performed pre-operatively in descending thoracic aortic aneurysm and Safi type V aneurysm repair. In Crawford type I, II, III, and IV aneurysm repairs, spinal drainage was normally performed pre-operatively. Spinal drainage was removed 3 days after surgery. Post-operatively, systolic blood pressure was maintained between 140 mmHg and 160 mmHg. Intraoperative neurological measurements such as motor-evoked potential were not used.

Statistical analysis

Data are presented as *n* (%) for discrete variables and as mean ± SD for continuous variables. Cox regression analysis was used to identify the predominant predictors for late aortic events of TBAD before surgical intervention. The actuarial freedom from late aortic events and survivals were computed using the Kaplan—Meier method and compared using the log-rank test. All statistical analyses were performed using JMP 9.0 software (SAS Institute Inc., Cary, NC, USA).

RESULTS

Of the 234 patients identified, 187 were male (mean age at the time of surgery 60.4 ± 13.0 years). A total of 132 patients had hypertension, while 32 had dyslipidemia (see Table 1).

A total of 216 patients were treated electively for FL aneurysm. Eighteen patients underwent emergency or urgent operation. The indications for urgent operation were rupture ($n = 7$) or continuous pain ($n = 11$). Fourteen (6.0%) patients had a partially thrombosed FL, 37 (15.8%) had a completely thrombosed FL, and 180 (76.9%) had a patent FL. In the patent FL group, 10 patients had three-channel aortic dissection. In three patients, the FL status was unknown, because enhanced CT scans had not been performed pre-operatively.

A total of 127 (54.3%) patients had descending thoracic aortic enlargement, and 107 (45.7%) had thoraco-abdominal aortic enlargement. The mean ± SD maximum AD was 58.4 ± 10.7 mm. If the aneurysm had enlarged >5 mm in 6 months, surgery was recommended, even if the maximum diameter was <50 mm. The mean interval between onset of TBAD and operation was 61 ± 54 months. There were no significant differences between FL patency and interval between onset and surgical intervention (Fig. 1).

The mean thickness of the FL was 37.3 ± 14.3 mm. The mean FL/AD ratio was 0.63 ± 0.20. In 123 (52.5%) patients, the FL/AD ratio was >0.7. There was no significant correlation between the FL/AD ratio and the interval between TBAD onset and operation ($r = .1213$). Cox regression analyses showed that neither the patent FL ($p = .50$) nor the FL/AD ratio (cut off ≥ 0.7; $p = .13$) was a significant predictor of the interval between TBAD onset and operation.

The operative details are shown in Table 2. DTAR was performed in 127 (54.3%) patients, while TAAR was performed in 107 (45.7%). In TAAR, the intercostal arteries were reattached individually in 74 cases, the visceral vessels were reattached in 84 cases, and beveled anastomosis was performed in 14 cases. Additionally, fenestration at the distal anastomosis site was performed in 138 (59.0%) patients.

The overall operative and in hospital mortality rates were 6.8% ($n = 16$) and 8.5% ($n = 20$), respectively (Table 3). For elective operations ($n = 216$), the operative and in hospital mortality rates were 4.6% and 6.0%, respectively. Major adverse outcomes occurred in 41 (17.5%) patients. Of these, permanent paraplegia occurred in five patients (2.1%), and paraparesis occurred in nine (3.8%). Stroke occurred in seven cases (3.0%), and a cardiac event in nine (3.8%). Moreover, pulmonary complications occurred in 78 (33.3%) patients.

Table 2. Operative data ($n = 234$).

Operative characteristic	*n* (%)
Previous aortic operation	138 (43.7)
Abdominal aorta	24 (7.6)
Thoracic aorta	122 (38.6)
Aortic replacement	
Descending thoracic aorta	127 (54.3)
Thoraco-abdominal aorta	107 (45.7)
Crawford extent I	9 (3.8)
Crawford extent II	65 (27.8)
Re-implanted intercostal arteries	74 (31.6)
Re-implanted visceral arteries	84 (35.9)
Bevelled	14 (6.0)
Perfusion strategy	
Left heart bypass	223 (95.3)
Deep hypothermia and circulatory arrest	6 (2.6)
Others	5 (2.1)

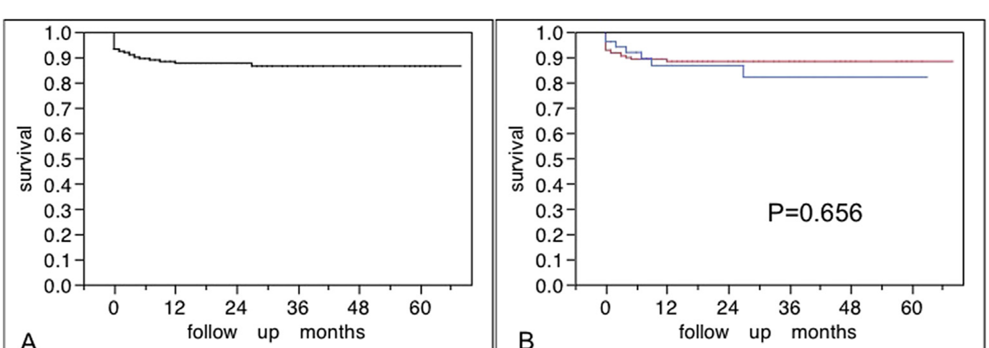

Figure 1. (A) Interval between onset of type B aortic dissection and operation of entire study group. (B) Interval between onset of type B aortic dissection and operation of each group. *p*-Values were calculated using the log-rank test.

Table 3. Operative results.

Variable	All ($n = 234$)	DTA ($n = 127$)	TAAA ($n = 107$)	p
Major adverse outcome	41 (17.5)	14 (11.0)	27 (25.2)	<.01
Overall operative death	16 (6.8)	5 (3.9)	11 (10.3)	.06
Elective ($n = 216$)	16 (4.6)	2/119 (1.6)	8/97 (8.3)	.02
In hospital death	20 (8.5)	8 (6.3)	12 (11.2)	.18
Spinal cord deficits	14 (6.0)	2 (1.6)	12 (11.2)	<.01
Permanent paraplegia	5 (2.1)	0 (0.0)	5 (4.7)	.01
Paraparesis	9 (3.8)	2 (1.6)	7 (6.5)	.05
Acute renal dysfunction	24 (10.3)	8 (6.3)	20 (18.7)	<.01
Dialysis at discharge	9 (3.8)	1 (0.8)	8 (7.5)	.01
Pulmonary complication	78 (33.3)	37 (29.1)	41 (38.3)	.14
Reoperation for bleeding	9 (3.8)	3 (2.4)	6 (5.6)	.20

Note. Data are n (%). DTA = Descending thoracic aneurysm; TAAA = Thoraco-abdominal aortic aneurysm.

DTAR was performed in 127 cases and TAAR in 107. The overall elective operative mortality was 3.9% (5/127) in DTAR and 1.7% (2/119) in DTAR. No paraplegia was observed after DTAR for chronic TBAD. Paraparesis was seen in 1.6% (2/127) of patients. For all TAAR operative mortality and paraplegia were 10.2% (11/107) and 4.7% (5/107). In elective TAAR, operative mortality and paraplegia were 8.2% (8/97) and 4.1% (4/97), respectively. In non-elective operations, operative mortality was 33.3% (6/18) (DTAR, $n = 3$; TAAR, $n = 3$). The causes of operative death were mesenteric ischemia ($n = 2$), multiple organ failure ($n = 1$), multiple embolism ($n = 1$), cerebral infarction ($n = 1$), and sudden death ($n = 1$).

The 1 and 3 year post-operative survival rates were 87.6% and 86.5%, respectively (Fig. 2). During the follow up period, re-intervention for pseudoaneurysm at an anastomotic site or graft infection was necessary in seven (3.0%) patients. In the follow up period, 24 (10.2%) patients required additional aortic operations, including operations unrelated to the primary dissection. Additional aortic operations, including aortic root replacement, total arch replacement, TAAR, TEVAR, abdominal aortic replacement (AAR), and endovascular aortic repair (EVAR) were performed in two, seven, four, three, five, and seven patients, respectively. Most cases of AAR and EVAR were intended staged interventions following primary open surgery. In the follow up period, four cases of type A dissection and one case of remnant aneurysm rupture were considered as aortic related deaths.

DISCUSSION

Recently advancements in TEVAR technology have resulted in expanded indications for TEVAR for TBAD.

For complicated TBAD accompanied by organ malperfusion, TEVAR is generally performed, and has been reported to achieve acceptable early outcomes. Alsac et al. performed TEVAR for acute complicated TBAD and achieved satisfactory early outcomes.[7] Similarly, Patel et al. and Shah et al. also reported on TEVAR for complicated TBAD[8,9]; where the 30 day mortality rate was 17.4%, and mean survival was 84.3 months. In addition they found that, while the risk of late mortality was associated with age, no association was observed for either the type or the number of malperfused vessels.

For uncomplicated acute TBAD, medical treatment with antihypertensive agents and rest has been shown to result in acceptable in hospital outcomes. Accordingly, in their systematic review, Fattori et al. reported a pooled early mortality rate of 6.4% with medical treatment.[6] However, TEVAR for uncomplicated TBAD remains controversial. Shah et al. found that TEVAR for acute uncomplicated TBAD was associated with a similar in hospital mortality rate as medical management,[9] whereas De Rango and Estrera reported that certain subgroups of patients with uncomplicated TBAD may benefit from early stent graft placement, although the identification of these patients remains difficult.[5] Nienaber et al. identified that aortic remodeling by TEVAR for early-phase type B dissection lead to the reduction of complications in the chronic phase.[10] However, in the present study, aortic expansion in the chronic phase was observed independently of FL status. It is true that the trial emphasizes the risk of rupture by the aortic expansion

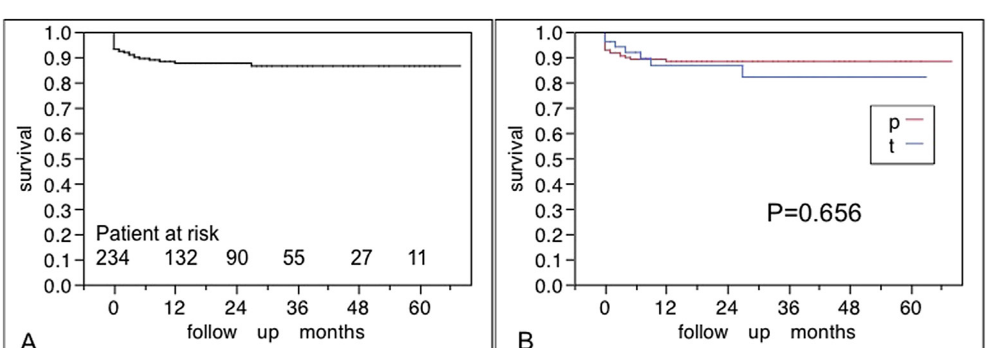

Figure 2. (A) Cumulative survival of entire study group. (B) Cumulative survival of each group. p-Values were calculated using the log-rank test. Note. p = patent false lumen; t = thrombosed or partially thrombosed false lumen.

in the chronic phase, which is why regular CT scans are essential even if patients undergo optimal medical treatment. When the aortic diameter has expanded, elective surgical intervention should be considered before a catastrophic event occurs. The basic strategy of the authors is open surgery, and the operative results are acceptable, especially in the elective setting. Open surgery for chronic dissection has a low re-intervention rate.

In addition, the significant predictors of late aortic events after TBAD are currently unknown. Some investigators have reported that a persistent FL may be a risk factor for adverse outcomes[11]; however, others have argued that aortic segments with a partially thrombosed FL are associated with a significantly higher annual growth rate than patients presenting with patent or complete thrombosis of the FL.[12]

TEVAR is commonly performed for chronic TBAD in many institutions, and has been demonstrated to be associated with relatively low mortality and high re-intervention rates.[6,13] However, there are numerous reports suggesting that open surgery is associated with a low re-intervention rate.[14] For these reasons, the basic strategy for uncomplicated TBAD at the authors' institution is conservative treatment in the acute phase and open surgery in the chronic phase if the patient presents with aneurysmal changes.

The objective of the present study was to retrospectively examine the results of open surgery for chronic TBAD, and the clinical features of the patients. The results revealed that it took an average of 61 $\pm$ 54 months (mean $\pm$ SD; median 43 months) until TBAD required surgical intervention; a satisfactory event free survival was achieved in these patients by medical treatment.

There was no significant relationship between the FL/AD ratio and the interval between onset of TBAD and surgery; Cox regression analyses subsequently showed that neither a patent FL nor an FL/AD ratio $\geq$0.7 was correlated with the time between onset of TBAD and operation.

Lastly, the operative outcomes for chronic TBAD showed satisfactory in hospital mortality and 1 and 3 year survival rates. Thus, considering the low re-intervention rate of open surgery, the strategy presented here for chronic aortic dissection is useful.

The present study had several limitations. First, the study was retrospective and limited to patients who underwent open surgery at the authors' institution. Several other parameters have been suggested as markers of late aneurysmal formation after TBAD including entry tear size and location, and extent of the dissection. These parameters could not be analyzed. The authors seldom consider TEVAR for chronic dissection—the basic strategy is open surgery. In this study, TEVAR for chronic dissection was performed in only two cases, and open surgery only rarely considered entry tear size and location of dissection.

Second, only 187 (79.9%) patients had information regarding the onset date of TBAD. Hence, predictors of late aortic events may have been identified if complete data regarding the onset date had been available. Third, this was a single center study with a limited number of patients, and no firm conclusions can therefore be drawn from the findings.

In conclusion, enlargement of uncomplicated TBAD in the chronic phase does not appear to be related to the thrombosis and diameter of FL, and open repair is associated with acceptable early outcomes and a low re-intervention rate, as well as fewer morphologic limitations. While these results should be considered in the treatment of TBAD, further prospective large scale studies are needed to confirm the findings.

CONFLICT OF INTEREST

None.

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