Toward the Best Treatment for Uncomplicated Patients With Type B Acute Aortic Dissection  
A Consideration for Sound Surgical Indication

Akira Marui, MD; Takaaki Mochizuki, MD; Norimasa Mitsui, MD; Tadaaki Koyama, MD; Fumiko Kimura, MD; Mayumi Horibe, MD

Background—In the treatment of type B acute aortic dissection without complications, better results are obtained if surgery is performed before enlargement of the aorta in patients who are predicted to show aortic enlargement and if drug-based treatment is continued for patients who are predicted to show no enlargement. The purpose of this study was to predict the acute-phase factors that may affect chronic-phase aortic enlargement by studying chronic-phase enlargement of dissections in patients without complications during the acute phase.

Methods and Results—In 101 patients with type B acute dissection who had no complications, univariate and multivariate factor analyses were performed to determine the predictors for chronic-phase enlargement (≥60 mm) of the dissected aorta. The independent predominant predictors for aortic enlargement in the chronic phase were a maximum aortic diameter of ≥40 mm and a patent false lumen during the acute phase. The values of actuarial freedom from aortic enlargement for the patients with a maximum aortic diameter of 40 mm and a patent false lumen at 1, 5, and 10 years were 43%, 33%, and 22%, respectively, whereas in patients with a maximum aortic diameter of <40 mm and a closed false lumen, the values were 97%, 94%, and 84%, respectively.

Conclusions—These results suggest that patients with type B acute aortic dissection who show a maximum aortic diameter of ≥40 mm and a patent false lumen should undergo surgery earlier during the chronic phase before enlargement of aorta, whereas patients with a maximum aortic diameter of <40 mm and a closed false lumen should continue to receive hypotensive therapy. (Circulation. 1999;100[suppl II]:II-275–II-280.)

Key Words: aorta • aneurysm • follow-up studies • risk factors • surgery

It has been generally advocated that patients who have type B acute aortic dissection without complications, such as rupture or organ ischemia, be treated with hypotensive drugs during the acute phase and that surgical treatment be selected if the aortic diameter becomes enlarged during the chronic phase.1–5 However, a number of patients who have successfully gone through the acute phase with medical hypotensive therapy often require surgery during the chronic phase due to aortic enlargement or, unfortunately, the aorta ruptures. Some recommend surgical treatment for all patients during the acute phase.6–8

However, some patients show good long-term results because the dissected aorta shows a natural course of recovery (ie, thromboembolization of the false lumen and a reduction in diameter). Patients who are expected to have a lower probability of chronic-phase aortic enlargement and a high likelihood of natural recovery should not undergo surgery during the acute phase because they are at a higher risk than are patients in the subacute or chronic phase in terms of fragility of the aortic wall.

We hypothesized that the following 2 therapeutic options for type B acute aortic dissection might provide better long-term results. The first option is surgery during the subacute or earlier chronic phase before aortic enlargement in patients who are expected to have a high likelihood of aortic enlargement. The second option is drug-based treatment for patients who are expected to show a natural course of recovery of the aortic dissection. In the present study, we examined which factors during the acute phase affect the chronic-phase enlargement of type B aortic dissection by studying chronic-phase enlargement of dissections in patients who had received successful drug-based hypotensive therapy during the acute phase.

Methods

Between January 1988 and July 1998, 109 patients were admitted to our institution during the acute phase (within 14 days of the onset) of type B acute aortic dissection. Of the 109 patients, 101 patients were entered into this study as cases treated successfully with hypotensive therapy during the acute phase. The reasons for the 8 exceptions included 5 cases of emergent surgery (thoracic aortic rupture in 2,
aortic enlargement during the chronic phase.

Patients were admitted to a critical care unit, where ECG and blood pressure were closely monitored. During the acute phase of dissection, nitrate, calcium channel antagonist, and β-adrenergic receptor blocker medications were administered intravenously to regulate systolic blood pressure and to reduce the velocity of left ventricular ejection (dP/dt). To maintain systolic blood pressure at <140 mm Hg during the chronic phase, several antihypertensive drugs, including nitrates, calcium channel antagonists, ACE inhibitors, or β-adrenergic receptor blockers, were administered orally. After discharge, patients were followed up at regular intervals, and blood pressure was measured every 1 month with the use of a standard bulk sphygmomanometer. The mean systolic blood pressure, which was obtained from serial blood pressure measurements during the chronic phase, was entered into the predictive variables for aortic enlargement (Table 1).

Follow-Up Study and Definitions
CT scanning (from 1988 to 1993 with model TCT-300, Toshiba Co; from 1994 to 1998 with ProSeed, Yokogawa Medical Systems) was performed every 2 to 26 months (mean, 17.4 months), depending on the aortic diameter and progression of aortic disease, to examine the serial maximum diameter of the dissected aorta. Aortic enlargement is a predictor of subsequent aortic rupture without surgical intervention. The criteria defining aortic enlargement during the chronic phase were (1) maximum diameter of the dissected aorta ≥60 mm, (2) rapid enlargement of the dissected aorta >10 mm/y, (3) rupture of the dissected aorta, and (4) rapid enlargement of ulcer-like projection (ULP) by >5 mm/y. These criteria conformed with the surgical indications for chronic type B aortic dissection at our hospital. We obtained the expansion rate of each dissected aorta or ULP by calculating the difference in diameter between the initial measurement and the most recent follow-up and dividing that value by the time interval between the 2 measurements.

Statistical Analysis
The Cox proportional hazards model was used to identify predominant predictors for aortic enlargement throughout the entire follow-up period with the use of univariate and stepwise multivariate analyses (entry and removal thresholds 0.05 and 0.1, respectively). For statistical analysis, all of the continuous variables were categorized as shown in Table 1. Freedom from aortic enlargement was computed according to the Kaplan-Meier technique, and event-free survival curves were compared with the use of the log-rank test. Unless stated otherwise, all results are expressed as mean ±SD. A value of P<0.05 was considered statistically significant. Data analysis was performed with the use of StatView J-4.5 for Macintosh.

Results
All 101 type B aortic dissection patients who had passed the acute phase with medical hypotensive therapy were followed up as outpatients. Follow-up data (blood pressure measurement every month and CT scan every 2 to 34 months) were 98% complete, and the mean follow-up time was 59 months (range, 2 to 125 months). Of the 101 patients, 60 patients continued to receive hypotensive therapy, whereas 41 patients underwent surgery during the chronic phase. Of 41 patients who underwent surgery, 4 patients died after the first surgical interventions during the chronic phase (2 of hemorrhage, 1 of acute renal failure, and 1 of bronchial occlusion with hemorrhage from aortopulmonary fistula). Two patients died of aortic rupture 24 and 66 months after the first operation, respectively. Three patients died of nontype B events (cancer, n = 2; suicide, n = 1) after surgery. Of the 60 patients receiving hypotensive therapy, 11 patients died during the follow-up period (3 of rupture of the dissected aorta, 4 of cancer, 3 of heart failure, and 1 of pneumonia). The rupture of dissected aorta was confirmed on autopsy. Although all 3 patients who died of aortic rupture had confirmed aortic enlargement, they...
did not undergo surgery because of advanced age (≥80 years old) and poor general condition.

Of the 101 patients, 43 met the criteria for enlargement of the dissected aorta during the chronic phase. In these 43 patients, the follow-up period from onset to enlargement was 2 to 120 months, with a mean follow-up time of 59 months. Of the 43 patients, 29 (67%) met the criterion of maximum aortic diameter of ≥60 mm, 7 (16%) met the criterion of rapid aortic enlargement, 4 (9%) met the criterion of rupture during the chronic phase, and 3 (7%) met the criterion of rapid enlargement of ULP. Precise data on the 12 variables for 43 cases are provided in Table 2. The values for actuarial freedom from aortic enlargement of the dissected aorta in all cases at 1, 5, and 10 years after the onset were 76%, 60%, and 47%, respectively.

The 12 variables, which are listed in Table 1, were correlated with aortic enlargement throughout the entire follow-up period with the use of univariate analysis (Table 3); a past history of cerebrovascular disease (P=0.37), hemodialysis (P=0.31), a patency in the false lumen (P=0.001), and a maximum aortic diameter of ≥40 mm (P<0.001) were found to be significantly correlated with enlargement of the dissected aorta. To determine the independent predictors for aortic enlargement throughout the entire follow-up period, forward stepwise Cox regression analysis was performed. Both a maximum aortic diameter of ≥40 mm (P<0.001) and blood status in the false lumen (P=0.024) were shown to be significantly predictive of enlargement with the use of multivariate Cox regression analysis. The hazard ratio for the presence of aortic diameter of ≥40 mm was 3.97 times higher than that for <40 mm, and the hazard ratio for the presence of patent false lumen was 2.09 times higher than that for closed false lumen.

To obtain a more accurate estimate of chronic-phase aortic enlargement, the 101 patients were divided into 4 subgroups according to 4 combinations of the 2 independent predictive variables selected with the use of multivariate Cox regression analysis: maximum aortic diameter of <40 mm and a closed

### TABLE 2. Patient Characteristics for Patients With and Without Enlargement

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Enlargement (n=43)</th>
<th>No Enlargement (n=58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male, n (%)</td>
<td>31 (72.1)</td>
<td>38 (65.5)</td>
</tr>
<tr>
<td>Age ≥70 y, n (%)</td>
<td>15 (34.9)</td>
<td>29 (50.0)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>36 (83.7)</td>
<td>42 (72.4)</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>8 (18.6)</td>
<td>6 (10.3)</td>
</tr>
<tr>
<td>Ischemic heart disease, n (%)</td>
<td>12 (27.9)</td>
<td>8 (13.8)</td>
</tr>
<tr>
<td>Cerebrovascular disease, n (%)</td>
<td>12 (27.9)</td>
<td>6 (10.3)</td>
</tr>
<tr>
<td>Hemodialysis, n (%)</td>
<td>4 (9.3)</td>
<td>2 (3.4)</td>
</tr>
<tr>
<td>LVEF ≥70%, n (%)</td>
<td>15 (34.9)</td>
<td>15 (25.9)</td>
</tr>
</tbody>
</table>

**Computed tomography findings during acute phase**

| Extent of dissection, n (%)                          | 15 (34.9)          | 25 (43.1)             |
| DeBakey, IIIa                                        | 28 (65.1)          | 33 (56.8)             |
| Patency in the false lumen, n (%)                    | 28 (65.1)          | 17 (29.3)             |
| Closed                                              | 15 (34.9)          | 41 (70.7)             |
| Maximum aortic diameter                              | 33 (76.7)          | 17 (29.3)             |
| ≥40 mm, n (%)                                        | 10 (23.3)          | 41 (70.7)             |
| <40 mm, n (%)                                        | 17 (39.5)          | 13 (22.4)             |

**Follow-up variables during chronic phase**

| Mean systolic blood pressure ≥140 mm Hg, n (%)       | 17 (39.5)          | 13 (22.4)             |

LVEF indicates left ventricular ejection fraction.

### TABLE 3. Results of Statistical Analysis

<table>
<thead>
<tr>
<th>Predictive Factors During Acute Phase</th>
<th>Univariate</th>
<th>Multivariate</th>
<th>Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1.41</td>
<td>0.235</td>
<td></td>
</tr>
<tr>
<td>Age ≥70 y</td>
<td>0.29</td>
<td>0.588</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>2.10</td>
<td>0.148</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.45</td>
<td>0.229</td>
<td></td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>2.87</td>
<td>0.090</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>4.33</td>
<td>0.037</td>
<td>0.083 1.83</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>4.65</td>
<td>0.031</td>
<td>0.166 2.00</td>
</tr>
<tr>
<td>LVEF ≥70%</td>
<td>0.96</td>
<td>0.327</td>
<td></td>
</tr>
<tr>
<td>Mean blood pressure</td>
<td>3.19</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>Type (DeBakey IIIa/b)</td>
<td>0.47</td>
<td>0.492</td>
<td></td>
</tr>
<tr>
<td>Patency of false lumen</td>
<td>10.17</td>
<td>0.001</td>
<td>0.024 2.09</td>
</tr>
<tr>
<td>Aortic diameter ≥40 mm</td>
<td>18.89</td>
<td>&lt;0.001</td>
<td>&lt;0.001 3.97</td>
</tr>
</tbody>
</table>

LVEF indicates left ventricular ejection fraction.
false lumen (group A), maximum aortic diameter of <40 mm and a patent false lumen (group B), maximum aortic diameter of ≥40 mm and a closed false lumen (group C), and maximum aortic diameter of ≥40 mm and a patent false lumen (group D). The values for freedom from aortic enlargement for group A at 6 months and 1, 5, and 10 years were 100%, 97%, 94%, and 84%, respectively; values were 93%, 87%, 66%, and 58% for group B; 90%, 79%, 52%, and 28% for group C; and 53%, 43%, 33%, and 22% for group D (Figure 1).

Discussion

The optimal treatment for patients with type B aortic dissection remains a matter of debate. Each cardiologist or surgeon determines the surgical indications for type B aortic dissection according to his or her experience and the surgical results of the institution.

Recently, however, it was advocated that patients who had type B acute aortic dissection without complications, such as rupture or organ ischemia, be treated with hypotensive drugs during the acute phase, because the mortality rate with this treatment is reported to be equal to or slightly better than that for surgical treatment during the acute phase.4,5,12–17 Surgical treatment should be selected if the aortic diameter becomes enlarged during the chronic phase; careful observation of aortic enlargement in all patients treated during the chronic phase is very important but very difficult. Unfortunately, some patients who have successfully gone through the acute phase with medical hypotensive therapy suddenly die during the chronic phase of aortic rupture; ideally, enlargement of the aorta should be predicted and surgery should be performed early, before the aorta becomes enlarged.6–8

The recommendations at several institutions are that surgical treatment be offered for all patients during the acute phase because the prevention of aortic rupture and organ ischemia through acute-phase surgery contributes to a better mortality or morbidity rate and because a number of patients with medically treated dissection have subsequent aortic enlargement and must undergo surgical treatment during the chronic phase.4,8,10,12,13,18 In addition, the surgical results for these chronic-phase cases of enlarged aorta are definitely not better than the results for acute-phase surgery because more extended surgery and concomitant reconstruction of visceral arteries and the narrowed true lumen are necessary, and because respiratory complications due to severe adhesion of the lung occur during most of these operations in patients in the chronic phase.9,16,17

However, surgical intervention must not be performed too prematurely in patients who have a low probability of aortic enlargement, because early surgery could be a cause of in-hospital death. In this study, we found that a number of patients without surgical interventions have good long-term results because the dissected aorta shows a natural course of recovery (ie, a reduction in diameter). Patients who have a lower probability of chronic-phase aortic enlargement and a high likelihood of natural recovery should not undergo surgery during the acute phase, because in terms of fragility of the aortic wall, surgery in the acute phase carries a higher risk than subacute or chronic-phase surgery. A natural course of recovery remains the optimal treatment for aortic dissections and should be the goal whenever possible. Therefore, we considered the 2 therapeutic options for type B acute aortic dissection that might provide better long-term results: surgery during the subacute or earlier chronic phase before enlargement of the aorta in patients who are expected to have a high likelihood of aortic enlargement and drug-based treatment for patients who are expected to show a natural course of recovery from aortic dissection.

Our results indicate that chronic-phase aortic enlargement of type B dissection can be predicted with 2 independent factors: maximum diameter of the dissected aorta and the patency of the false lumen, which may be obtained at the onset of dissection. What kind of acute-phase factors do patients have who will show a high incidence of aortic enlargement during the chronic phase? The value for freedom from aortic enlargement in patients with a maximum aortic diameter of ≥40 mm and a patent false lumen (group D) at 6 months was 53%, indicating that about half of the group D patients required surgical intervention within 6 months from onset (Figure 2). The event-free rates of group D at 5 and 10 years were low (33% and 22%, respectively). These results suggest that group D patients undergo surgery during the subacute or early chronic phase before enlargement of the aorta. We compared group D patients with patients who had a maximum aortic diameter of ≥40 mm and a closed false lumen (group C). The event-free rates of group D at 6 months and 1 year fell abruptly to 53% and 43%, respectively, whereas those of group C remained relatively good (90% and

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**Figure 1.** Kaplan-Meier event-free curves indicate 4 types of combinations of predominant predictive factors during acute phase: curve A, maximum aortic diameter of <40 mm and closed false lumen; curve B, maximum aortic diameter of <40 mm and patent false lumen; curve C, maximum aortic diameter of ≥40 mm and closed false lumen; and curve D, maximum aortic diameter of ≥40 mm and patent false lumen.

**Figure 2.** Comparison of 2 event-free curves for aortic enlargement during chronic phase: curve C, maximum aortic diameter of ≥40 mm and closed false lumen; and curve D, maximum aortic diameter of ≥40 mm and patent false lumen.
79%, respectively). However, by 10 years, the event-free rate of group C at 10 years (28%) was approaching that of group D (22%). Moreover, the event-free curves of groups C and D were not significantly different from each other (P=0.14). These results indicate that the number of patients who showed aortic enlargement during the chronic phase was equivalent in groups C and D in the long term, although the rate of expansion of the aortic diameter of group C was slower than that of group D; therefore, earlier surgery should be considered for group C patients.

We suggest that patients with a maximum aortic diameter of ≥40 mm and a patent false lumen undergo surgery during the subacute or early chronic phase, because the mortality rate for surgical treatment for patients with acute type B aortic dissection without complications has recently decreased to ~10% \(^3,5\); the surgical results for late chronic-phase cases of enlarged aorta are clearly no better than the results for acute-phase surgery, and the strength of the dissected aorta during the early chronic phase is satisfactory. We would consider earlier surgery for patients with a maximum aortic diameter of ≥40 mm but a closed false lumen.

Not all patients should undergo surgery earlier during the chronic phase. In this study, we found that a number of patients without surgical interventions showed good long-term results because the dissected aorta showed a natural course of recovery. Event-free rates of patients with a maximum aortic diameter of <40 mm and a closed false lumen (group A) at 1, 5, and 10 years were satisfactory (97%, 94%, and 84%, respectively) (Figure 3). No patients died of aortic events, and 14 patients (35%) showed a reduction in aortic diameter; patients with a maximum aortic diameter of <40 mm and a closed false lumen are expected to have a high likelihood of natural course of recovery. However, there is 1 important result: although only 4 patients (10%) of group A showed an aortic enlargement, 3 of 4 causes of enlargement were due to rapid growth of the ULP. Thus, with the exception of patients with ULP, patients with a maximum aortic diameter of <40 mm and a closed false lumen are expected to have satisfactory long-term results.

The 55% incidence of closed false lumen in the acute phase is much higher than that reported in previous series\(^5,19\). Although the reasons for this are not clear, we propose the following explanation. We believe that at most of the other institutions, CT scanning is not always performed on patients with chest or back pain who do not have specific findings on ECG, chest radiography, or blood analysis. However, we routinely perform enhanced CT scanning on all patients with chest or back pain. We believe that closed false lumen and small aortic diameter were often accidentally detected on routine CT scanning in patients with chest or back pain who did not have specific findings on chest radiography, such as wide mediastinum or large aortic diameter. We believe that these patients may be often overlooked at other institutions; this is a possible reason for the high incidence of closed false lumen in patients in the acute phase at our institution.

Because the event-free curve for patients with a maximum aortic diameter of <40 mm and a patent false lumen (group B) was significantly lower than that of group A patients (P=0.021), group B patients were expected to have a higher incidence of aortic enlargement than group A patients during the chronic phase. However, we believe that group B patients can be treated medically, because 60% of group B patients did not show aortic enlargement, and none died of aortic events. With more careful observation of aortic diameter, patients with a maximum aortic diameter of <40 mm and a patent false lumen should be treated medically as long as the aortic diameter does not become enlarged.

In conclusion, if patients with type B acute aortic dissection show a maximum aortic diameter of ≥40 mm and a patent false lumen at onset, they are predicted to have a high incidence of aortic enlargement during the chronic phase. We suggest that they undergo surgery during the subacute or early chronic phase due to the difficulties associated with surgery during the late chronic phase. We recommend the consideration of early surgery for patients with a maximum aortic diameter of ≥40 mm but a closed false lumen; however, patients with a maximum aortic diameter of <40 mm and a closed false lumen should continue to receive hypotensive therapy because they are predicted to have a low probability of aortic enlargement and to have a high likelihood of a satisfactory course of recovery of the dissected aorta. Patients with a maximum aortic diameter of <40 mm and a patent false lumen can also be treated medically with more careful observation of the aortic dissection.

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References


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