Aortic cross-sectional area/height ratio timing of aortic surgery in asymptomatic patients with Marfan syndrome

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It is difficult to determine when to attempt prophylactic aortic repair in patients with Marfan syndrome before aortic dissection occurs.[1-5] Because stature clearly influences aortic diameter, we believed it was important to evaluate whether aortic cross-sectional area indexed to height would be of value in the decision of timing of surgical repair.

Methods

Between 1992 and 2001, 103 patients and their families were seen for Marfan syndrome, of whom 43 underwent operations. Symptoms and presentation of these 43 patients were graded as previously described[4]: 29 had no symptoms (grade 1) or minimal symptoms (grade 2: occasional chest discomfort or minor symptoms, such as dysphagia, hoarseness, palpitations), and 14 had persistent symptoms (grade 3: ongoing chest pain or discomfort) or an acute event (grade 4: acute aortic dissection, rupture, shock, or acute aorta-related event).[4] For those 23 patients with aortic dissection, the diameter of the aorta is shown in Table 1. The ratio of the cross-sectional area in square centimeters to the patient's height in meters was calculated, and we determined that a ratio of greater than 10 would be an indication for surgical intervention ($r^2\pi[cm^2]$/Height[m]) on the basis of our previous analysis of patients with aortic dissection. Statistical analysis was done with the Student *t* test.

Results

All 43 patients survived the operations, and 1 had a mild stroke after reoperation from malperfusion of a carotid dissection extending to the carotid bifurcation. For those patients with aortic dissection, the mean ratio was 17.5 (SD 8.15), and for the patients without dissection, the ratio was 13.3 (SD 4.5, $P = .049$). There was no difference in ratios between male and female patients, although in the male patients without dissection, the mean ratio was 12.85 (SD 5.1), and for those with aortic dissection, the mean ratio was 20.0 (SD 10.0, $P = .027$). No patient in our Marfan syndrome clinic who was being followed up and monitored had an aortic dissection during this period. The patient's maximum aortic diameter to normal expected mid-ascending aortic diameter was also examined according to the patient's height by using a mid-ascending aortic diameter of 32 mm for heights of 168 to 178 cm and 39 mm for heights of greater than 178 cm. At a ratio of twice the normal expected value, only 4 (19%) of the 21 patients with dissection would have undergone surgical repair; at a ratio of 1.5 times the normal expected value, 4 (19%) of the patients would not have had an operation. For patients without dissection, at a ratio of twice the normal expected value, only 1 (4.5%) of 22 would have had an operation, and at 1.5 times the expected normal value, 8 (36%) patients would not have had an operation on the basis of aortic ratios.

TABLE 1. Diameter of the aorta in patients with aortic dissection

Diameter (cm)	n
4.0-4.4	1 (5%)
4.5-4.9	2 (10%)
5.0-5.4	6 (28%)
>5.5	12 (57%)

Discussion

The current recommendation that asymptomatic patients with Marfan syndrome be operated on when the aortic diameter exceeds 5 cm, or even the more conservative amount of 5.5 cm, results in some patients having acute aortic dissection before the threshold size for prophylactic repair.[1-7] The importance of this is that approximately 40% of patients will immediately die of acute aortic dissection, and a further 10% to 20% will die during emergency operations. Furthermore, the data from Stanford[5] show that in patients operated on for Marfan syndrome with aortic dissection, the 5-year survival is reduced to 54% because of late rupture or mortality from reoperations.

Clearly, on the basis of this study and others,[1-7] acute aortic dissection occurs in patients at a diameter of less than 5 cm. In our previous analysis of 102 patients with Marfan syndrome with aortic dissection, dissection even occurred in 2 patients in whom the ascending aorta was of a normal size, although the aortic root itself and the sinus of Valsalva were enlarged. In the current analysis of the patients in this series, it should be noted that aortic dissection was present in 15% of patients with a diameter of less than 5 cm. Similarly, in the study by Gott and colleagues,[7] about the same incidence was found (ie, in 15% of patients with dissection of the aorta, the size was <5 cm). This is further supported by the careful study of Shores and colleagues,[6] who looked at long-term follow-

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up with and without β-adrenergic blockade and interim adverse events. Thus, considering that the operative mortality rate in our patients with asymptomatic aneurysms (grade 1) or patients with minimal symptoms (grade 2) was zero after elective operations and that in our[4] previous study of 151 patients with Marfan syndrome undergoing surgical repair 1% died in the grade 1 category and 3% in the grade 2 category, we conclude that earlier operations are justified in some patients with Marfan syndrome. Of interest, intimal tears without extension of the dissection may predate a classic dissection in patients with Marfan syndrome.[1]

Assuming that some patients will require surgical repair at a diameter of less than 5 cm, the question remains whether this indication can be better refined because male and female patients clearly differ in height. Although it has been suggested that aortic size be indexed to body surface area (eg, 1.5 times the expected aortic size for body surface area), the problem is that patients with Marfan syndrome, particularly women, are often quite obese. Thus, patients in this group would potentially have a larger aorta before surgical repair was indicated. Moreover, these obese patients are frequently hypertensive and may be more prone to aortic dissection. Under this guideline, a tall male patient may have to reach an aortic diameter of 6.3 cm before an operation is indicated, a size that appears to be excessive with our current understanding of the risk of rupture or dissection according to aortic size. Similarly, on the basis of our data, a ratio of twice or 1.5 times the expected normal value would have resulted in 81% or 19%, respectively, of patients not having an operation before dissection.

For example, a 5-foot 11-inch patient would have to have an aorta larger than 58.5 mm for surgical intervention to be considered at a ratio of 1.5 times the normal expected value. Nonetheless, on the basis of the ratio we are suggesting should be used, a 5-feet 6-inch (160 cm) female patient would have a cross-sectional area/height ratio of greater than 10 when the aorta reaches a diameter of 4.7 cm. Interestingly, this is the diameter that we suggested previously should be considered as an indication for an operation in some patients, particularly with a family history of aortic dissection.[4] Similarly, a 6-foot 4-inch (190 cm) male patient would reach the threshold at a diameter of 5 cm. Furthermore, this ratio also takes into account the exponential risk of dissection or rupture according to aortic radius rather than using a linear risk according to diameter. The work by Vasan and colleagues[8,9] would suggest that the use of absolute height for referencing normal aortic sizes is the best ratio to use. Furthermore, on the basis of the sizes recorded for our patients in whom aortic dissection occurred, approximately 1 SD below the mean ratio would also have resulted in a threshold of a ratio of approximately 10 being reached.

Thus, we would recommend that patients who present with a ratio of greater than 10 on initial examination should be scheduled for an elective prophylactic operation, particularly because this is largely curative, and valve-sparing operations can be more frequently offered. Surgical intervention is often only palliative in acute dissection, and with chronic dissection, such intervention is therapeutic but not curative, with patients requiring ongoing treatment and follow-up. A larger ratio may also be used in non-Marfan patients.

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