CLINICOPATHOLOGIC CORRELATIONS

Dissecting Aortic Aneurysm Associated with Congenital Bicuspid Aortic Valve

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SUMMARY Among 119 cases of fatal dissecting aneurysm of the aorta, exclusive of those iatrogenically caused or associated with arachnodactyly or aortic stenosis, there were observed 11 cases of congenital bicuspid aortic valve (9%). The ages ranged from 17 to 69 years, five of the patients being 29 years old or younger. Among the latter, three had coarctation of the aorta and one had Turner's syndrome without coarctation. In one of the older patients, aortic insufficiency was present. Hypertension was either established or inferred from cardiac weight in 73% of the cases.

In each case, cystic medial necrosis of the aorta was present. Prolapse of valves other than the aortic was observed in 45% of the cases with bicuspid aortic valve.

Compared to an estimated incidence of bicuspid aortic valve of about 1 to 2% in the population, the high incidence among subjects with dissecting aneurysm suggests a causative relationship between bicuspid aortic valve and aortic dissecting aneurysm.

Among subjects with dissecting aneurysm of the aorta, the most common background is hypertension. Less commonly, extensive cystic medial necrosis, either as part of obvious arachnodactyly (Marfan's syndrome) or as an isolated condition, is present. It has also been observed that aortic valvular disease, particularly aortic stenosis, may become complicated by dissecting aneurysm of the aorta. In such cases, as in hypertension, some degree of cystic medial necrosis is present but characteristically the degree of this change is less than in classical arachnodactyly.

In 1953, Gore, studying 38 cases of dissecting aneurysm of the aorta in individuals under 40 years of age, found that in nine of the cases a congenital bicuspid valve was present (24%). In one of his cases coarctation of the aorta was associated. In 1967, Huntington and Hirst described the case of a non-Marfanoid 16-year-old girl with nonstenotic bicuspid aortic valve and cystic medial necrosis of the aorta in whom dissecting aneurysm of the aorta had occurred.

Following the appearance of these reports, McKusick in 1972 described in a father and son, each with nonstenotic bicuspid aortic valves, the presence of cystic medial necrosis of the aorta and dissecting aneurysm. It was the view of McKusick that neither of his subjects harbored the features of arachnodactyly.

On the basis of the quoted observations, we were stimulated to review the aortic valves in our specimens with dissecting aneurysm of the aorta.

Observations

In the Cardiovascular Registry of the Miller Division of United Hospitals, exclusive of cases with arachnodactyly or iatrogenic causes, there are 125 specimens of heart and aorta with dissecting aneurysm of the aorta. From the 125 cases, the six cases of aortic stenosis previously reported were excluded. There remained 119 cases of dissecting aneurysm of the aorta without stenotic aortic valves. Among these were found 11 cases of congenital bicuspid nonstenotic aortic valves (9%). Nine of the subjects were men, and two were women. The ages ranged from 17 to 69 years. In five of the cases the patients were aged 29 years or younger. In each instance the internal tear was in the ascending aorta. In one case, the extent of intramural dissection of blood was limited, while in the remainder there was classical extensive dissection. In each case, death resulted from rupture of the outer wall of the false passage with complicating hemopericardium.

In nine of the 11 cases, the aortic valvular cusps were noncalcified and appeared to have been competent (fig. 1). In one case involving a nonhypertensive 60-year-old woman with a cardiac weight of 350 g, there was calcification of the raphe of the valve but flexibility of the cusps had been maintained, suggesting that the valve had not been stenotic (fig. 2a). In a case involving a 60-year-old man, the aortic cusps showed fibrosis, mild calcification and retraction (fig. 2b). Aortic insufficiency resulted. The heart was markedly enlarged, weighing 890 g.

Coarctation of the aorta was associated in three patients. In two of these (aged 17 and 20 years), this anomaly had not been treated, while in the third case (aged 29 years) the coarctation had been resected two months prior to the time of the fatal dissecting aneurysm. Hypertension had persisted after the surgical treatment.

A 27-year-old woman without coarctation of the aorta manifested the features of Turner's syndrome (fig. 3).

As judged from history or cardiac weight, hypertension had been present in eight of the cases (73%).

Histologic examination was done of the ascending aortae. This revealed cystic medial necrosis in each case. In each instance, easily apparent accumulations of amorphous basophilic material were present in the media. In relation to some accumulations, the elastic fibers had maintained their continuity, while in other instances there was associated in-
terruption of elastic fibers (grades 2 and 3, respectively, according to the criteria of Carlson and associates9) (fig. 4).

In cases with prolapsed ("floppy") valves, cystic medial necrosis of the aorta may be associated. For this reason, we examined in each specimen the atrioventricular and pulmonary valves for gross evidence of this change. Prolapse, usually of mild degree, was considered to be present in one or more of the valves in five of the 11 cases (45%). In one case, only the tricuspid valve was involved and in the four others the mitral valve was involved, either alone or in association with the tricuspid and/or pulmonary valves (fig. 5).

Comment
Dissecting aneurysm of the aorta may be viewed as a complication of disproportion between the strength of the aorta, on one hand, and intraluminal pressure, on the other. Classically, in arachnodactyly, hypertension is not present
but cystic medial necrosis of the aorta is extensive. The weakness imparted to the aorta by the latter process appears to be an adequate explanation for the common occurrence of aortic dissecting aneurysm in arachnodactyly. In hypertensive subjects, whether or not dissecting aneurysm is present, cystic medial necrosis of the aorta is common. Classically, however, the degree of cystic medial necrosis is mild or minimal, leaving one with the view that in the usual case of dissecting aneurysm of the aorta in a hypertensive subject, the luminal pressure plays a greater role than the cystic medial necrosis.

In aortic stenosis the factors leading to dissecting aneurysm may be a combination of the weakness of the aorta imparted by cystic medial necrosis and the poststenotic hemodynamic changes.

**Figure 3.** Bicuspid aortic valve and internal tear involving the ascending aorta in the case of a 27-year-old woman with Turner's syndrome.

**Figure 4.** Cystic medial necrosis of the aorta of varying degrees and retraction of interrupted segments of aortic media. a) From a 17-year-old boy with coarctation of the aorta. Elastic tissue stain; ×32. b) From a 29-year-old man in whom coarctation of the aorta had been treated two months prior to the development of dissecting aneurysm. In addition to the medial changes, there is shown in the lower part of the illustration the intramural hematoma of dissecting aneurysm. Elastic tissue stain; ×31. c) From the 60-year-old man whose aortic valve is illustrated in figure 2b. Extensive interruption of medial elements. Elastic tissue stain; ×30.
Hypertension had been identified in 1–2%. The occurrence of a congenital bicuspid aortic valve in from 9% (this study) to 24% (Gore) of cases of dissecting aneurysm suggests a factor that is more than coincidental. The basis for the associated cystic medial necrosis may perhaps be the same as in cases of aortic stenosis in which the dynamics of aortic stenosis underlie the appearance of cystic medial necrosis. The nonstenotic bicuspid aortic valve may, in fact, possess certain stenotic features.

McKusick has suggested that since the congenital bicuspid aortic valve may be associated with disease of the aorta, as coarctation, the cystic medial necrosis may be yet another congenital aortic anomaly. Some support for such a concept comes from the tendency for prolapsed or floppy valves also to be present.

The inordinately high incidence of bicuspid aortic valve among cases of dissecting aneurysm suggests that, even though hypertension is commonly, though not universally, associated, the valvular abnormality exerts certain factors that underlie the complication of dissecting aneurysm. Such factors may include a stenotic tendency of the valve with secondary cystic medial necrosis of the aorta.

The incidence of aortic dissecting aneurysm varies widely among studies. Roberts reviewed 85 cases of congenital bicuspid valve and observed 61 cases of calcific aortic stenosis, 11 cases of aortic insufficiency (eight with bacterial endocarditis) and 13 normally functioning valves. No instance of aortic dissecting aneurysm was found. Fenoglio and associates observed that among 152 pathologic specimens with congenital bicuspid aortic valve there were eight cases of dissecting aneurysm. Four of these showed aortic stenosis (two with coarctation of the aorta), three with aortic insufficiency and one in which the aortic valve was neither stenotic nor incompetent.

In each of the 11 cases observed by us, the congenital bicuspid valve was not stenotic and the subject did not exhibit the features of arachnodactyly. In one case, aortic insufficiency was present. Cystic medial necrosis of mild to moderate degree was present in the ascending aorta in each case. Hypertension had been identified or inferred from cardiac weight, or both, in eight of the 11 cases. Some causative factor for the dissecting aneurysm must be attributed to the hypertension in these eight cases, while in the three cases without evidence of hypertension the aortic medial weakness caused by cystic medial necrosis was perhaps the important factor in underlying the dissecting aneurysm.

It has been estimated that the incidence of congenital bicuspid aortic valve in the general population is about 1–2%. The occurrence of a congenital bicuspid aortic valve in from 9% (this study) to 24% (Gore) of cases of dissecting aneurysm suggests a factor that is more than coincidental. The basis for the associated cystic medial necrosis may perhaps be the same as in cases of aortic stenosis in which the dynamics of aortic stenosis underlie the appearance of cystic medial necrosis. The nonstenotic bicuspid aortic valve may, in fact, possess certain stenotic features.

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References

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Circulation. 1978;57:1022-1025
doi: 10.1161/01.CIR.57.5.1022

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