Aortic regurgitation was the commonest functional anomaly among younger patients in a group of 63 individuals with a diagnosis of bicuspid aortic valve. With increasing age, a rise in the number with combined aortic valve disease and aortic stenosis was observed. Aortic dilatation was found in 65% of cases. Dilatation was independently associated with age and transvalvular aortic gradient.

Key words: Bicuspid aortic valve. Valvular dysfunction. Aortic dilatation.

INTRODUCTION

Although ageing among the general population is known to be related to aortic dilation and degenerative aortic valve disease, there is little information on these effects in patients with a bicuspid aortic valve (BAV).

The purposes of the present study were to define the functional alterations of the aortic valve and the presence of aortic dilatation in patients diagnosed with BAV at a general hospital, as well as to describe the variables related to aortic dilatation in these patients. In particular, the effect of age was studied.

METHODS

We studied patients over 14 years of age diagnosed with BAV by echocardiography between January 1999 and December 2003.

An Acuson Aspen Advanced ultrasound system was used, with BAV defined by transthoracic echocardiography findings of 2 clear cusps on the short-axis parasternal view, with or without a raphe. The diagnosis required agreement between 2 observers. In the cases in which the transthoracic echocardiogram was indicative of BAV, but not definitive, transesophageal echocardiography was required to establish the diagnosis.

The variables analyzed were age, sex, height, body surface area, hypertension, vascular disease (myocardial infarction, stroke, or peripheral vascular disease), aortic root diameter measured at the aortic sinuses (in mm and mm/m²), maximum diameter of the ascending aorta (in mm and mm/m²), and presence and severity of stenosis and aortic regurgitation. Aortic stenosis was established at a mean gradient of ≥10 mm Hg. Stenosis was classified as severe at a mean gradient of ≥45 mm Hg. Aortic regurgitation was assessed according to the usual criteria based on an overall assessment of jet width in the left ventricular outflow tract, signal intensity and depth, regurgitation slope, and left ventricular size. We considered aortic root and/or ascending aorta dilatation to exist when the indexed diameter was >21 mm/m². Aortic dilatation was defined as dilation of at least 1 of these 2 segments.

Effect of Age on Valvular Dysfunction and Aortic Dilatation in Patients With a Bicuspid Aortic Valve

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Efecto de la edad en la disfunción valvular y la dilatación aórtica en pacientes con válvula aórtica bicúspide

En 63 pacientes diagnosticados de válvula aórtica bicúspide, la insuficiencia aórtica fue la alteración funcional más frecuente en los pacientes más jóvenes, mientras que con el envejecimiento se observó un aumento de casos con doble lesión y estenosis aórtica. Se detectó una dilatación aórtica en el 65% de los casos. La edad y el gradient transvalvular aórtico eran factores independientes relacionados con la dilatación.

Palabras clave: Válvula aórtica bicúspide. Disfunción valvular. Dilatación aórtica.
Qualitative variables were compared by the $\chi^2$ or Fisher’s exact test, where applicable. Quantitative variables were compared with Student $t$ test. Logistic regression analysis was used to determine the independent factors related to aortic dilation, introducing as a block the variables with $P<.10$ in the univariate analysis and applying the stepwise method. Linear correlations between age/aortic transvalvular gradient, age/aortic diameter, and aortic transvalvular gradient/aortic diameter were analyzed. Statistically significant differences were considered to exist when $P<.05$.

RESULTS

Sixty-three patients were diagnosed with BAV. The clinical characteristics are shown in Table 1. Aortic coarctation was diagnosed or known in 3 cases.

Valvular Dysfunction

The most frequent functional alterations were aortic regurgitation (44%) and double aortic lesion (38%) (Table 2). The distribution of the various lesions according to age is presented in Figure 1. The same data is shown in the subset of patients with severe valvular dysfunction in Figure 2. Only 17 patients (27%) had little or no functional alteration. Patients with isolated aortic regurgitation were younger than those with aortic stenosis, whether isolated or associated with regurgitation (40±15 vs 54±13 years; $P=.001$). With increasing age, we observed a decline in the proportion of patients with isolated aortic regurgitation and a rise in the proportion of patients with double aortic lesion and aortic stenosis (Figures 1 and 2). There was an acceptable linear relationship between age and transvalvular aortic gradient ($r=0.4, P=.001$).

Aortic Dilation

The mean diameters of the aortic root and ascending aorta are shown in Table 1. Dilation was detected in the aortic root in 26 cases (37%) and in the ascending aorta in 33 cases (52%). Aortic dilation was present in 41 patients (65%), including 10 of the 17 (59%) patients with no functional alterations or with mild valvular dysfunction. In the univariate analysis, age and aortic stenosis, when considered both as a qualitative and quantitative variable (mean...
transvalvular gradient), were found to be related to aortic dilation (Table 3). Patients with dilation were older than patients without dilation (52±13 vs 34±16 years; \( P < 0.001 \)); 29 of the 35 (83%) patients older than 45 showed dilation. In the logistic regression, age (odds ratio [OR] = 1.06 per year; \( P = 0.01 \)) and aortic stenosis (mean transvalvular gradient) (OR = 1.07 per mm Hg; \( P = 0.03 \)) were maintained as variables related to aortic dilation. A good linear relationship was observed between age and the aortic root and ascending aorta diameter (Table 4), but not between aortic transvalvular gradient and these diameters.

**DISCUSSION**

**Aortic Valve Dysfunction**

Several authors have described the functional alterations detected by echocardiography in BAV patients. Hahn et al reported a predominance of aortic regurgitation, whereas stenosis was the most frequent finding in 2 recent studies among pediatric patients with BAV. Nevertheless, there may be some bias in these series because the patients were from referral hospitals with cardiac surgery departments and were studied retrospectively.
In our study we observed a high prevalence of aortic regurgitation, which was the most frequent valvular dysfunction in patients less than 50 years old. Aortic regurgitation in patients with BAV is considered to be predominantly the result of prolapse or retraction of 1 of the valves (usually, the one with the raphe) and the consequences of aortic root and ascending aortic dilation on valve function.

In particular, we highlight the relationship between aortic stenosis and age. In patients older than 50 with BAV, stenosis is mainly due to an accelerated degenerative process in the abnormal valve. This would explain the smaller percentage of patients with isolated aortic regurgitation and the resulting higher percentage of patients with double aortic lesion we observed with ageing.

**Aortic Dilation**

Histological alterations in the aortic tunica media indicative of a degenerative process have been reported in patients with BAV; this would lead to aortic wall weakness and subsequent dilation. In our study, age and aortic stenosis were independent factors related to aortic dilation. Increasing age has been linked to degeneration of the tunica media, which makes the vessel susceptible to a loss of distensibility and dilation due to increased circumferential stress. Our results indicate that the known degenerative process of the aortic media described in patients with BAV is favored by ageing. With respect to aortic stenosis, although BAV is associated with aortic dilation, aortic stenosis has been described as contributing to dilation whether or not there are functional alterations. We have observed that this dilation is more frequent as the degree of stenosis is higher. The turbulent flow generated by stenosis appears to contribute to dilation. Furthermore, we found that significant valvular dysfunction is not necessarily associated with aortic dilation, since more than half the patients with no functional alterations or with mild valvular dysfunction presented aortic dilation.

**CONCLUSIONS**

In patients with BAV diagnosed in a general hospital after childhood, aortic regurgitation is the most frequent functional abnormality among the younger patients. Aortic stenosis is usually detected in older patients and typically associated with regurgitation. Aortic dilation is common and is related to age and aortic transvalvular gradient. Since most patients with BAV develop valvular dysfunction and aortic dilation, we believe that long-term clinical and echocardiographic follow-up should be undertaken, even though significant alterations are not found at the time of diagnosis.

**REFERENCES**