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Natural and Modified History of Isolated Ventricular Septal Defect: A 17-Year Study

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SUMMARY. **We studied 882 cases of isolated ventricular septal defect (VSD) diagnosed from 1971 to 1988 with a mean follow-up period of 9.5 years. They represent 22.5% of all congenital heart defects diagnosed in this period. Six hundred eighty-three children (77.4%) did not develop symptoms, had small defects, and the rate of spontaneous closure was high (40.2%). The remaining 199 children presented symptoms; at the initial catheterization 25, 65, 107, and 2 cases were grouped in hemodynamic groups 2, 3, 4, and 5–6, respectively, on the basis of pulmonary flow and resistance. Only seven patients (0.7%) developed aortic regurgitation, and only five patients (0.5%) developed infective endocarditis. Complete surgical correction was performed in 137 children (15.5% of the total cases), with surgical mortality decreasing from 21.4% before 1983 to 3.5% afterward. Overall mortality was 3% for the entire cohort, 0% for hemodynamic groups 1 and 2, 3% for group 3, and 25% for hemodynamic groups 4–6. About two thirds of the deaths took place between 1 month and 1 year of life, and one thirds of the deaths occurred before surgical treatment. Surgical mortality rates for hemodynamic groups 2, 3, and 4 were 0, 4.7, and 15.3%, respectively. Actuarial survival curves show an important improvement in the prognosis after 1983. Our results stress the importance of early surgical complete correction on patients with large defects and severe hemodynamic changes.**

KEY WORDS: **Ventricular septal defect — Infants — Congenital heart defects — Surgical repair**

Isolated ventricular septal defect (VSD) is the most common of all congenital heart defects and has been the subject of numerous publications concerning the many aspects of its diagnosis, treatment, and natural history [2, 4, 7]. In particular, there has been much debate on the indications of surgical correction and on the best age for the operation. The surgical mortality rate and the risk of developing vascular pulmonary disease in uncorrected large defects are two factors that should be weighed when deciding treatment [3, 6, 14]. The general approach taken to the management of children with VSD has changed with time, but there are not many publications on the influence of changing therapeutic criteria on prognosis [11, 12]. We have reviewed here the natural and modified history of the cases of isolated VSD diagnosed in our Hospital, a reference center for a population of 4 million in eastern Spain, since 1971.

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Patients and Methods

From January 1971 to January 1988, 882 children were diagnosed as having isolated VSD at the Children's Hospital "La Fe" of Valencia, Spain. These patients accounted for 22.5% of the 3920 children with congenital heart defects diagnosed in this Hospital during this 17-year period. Patients with other cardiac defects or with associate pulmonary stenosis or aortic regurgitation at the initial presentation were excluded.

Diagnostic Methods

The majority of the children, 643 cases, were diagnosed by clinical data and noninvasive diagnostic methods. Only 239 (27%) were diagnosed by invasive hemodynamic methods. The reasons for submitting them to the latter were the procurement of information not apparent or available by other noninvasive means, particularly when there were symptoms (congestive heart fail-

ure, fatigue upon feeding in infants, retarded growth) or the possibility of surgical treatment was being considered. Improvements in echocardiographic techniques obviated the need for catheterization in some cases in the last years of the study. Complete spontaneous closure was demonstrated by absence of murmur and normal two-dimensional echocardiography.

Hemodynamic State

The patients diagnosed by invasive methods were categorized at the initial catheterization into one of the following categories, according to the classification of Kidd and Keith [9, 10]:

Group 1: Low pulmonary flow and low resistance. A pulmonary/systemic flow ratio of less than 2 : 1 and a systemic/pulmonary resistance ratio of over 7 : 1 (blood gases showing no CO_2 retention).

Group 2: Pulmonary/systemic flow ratio of more than 2 : 1 and a systemic/pulmonary resistance ratio of greater than 7 : 1.

Group 3: Pulmonary/systemic flow ratio of more than 2 : 1 with a slightly altered systemic/pulmonary resistance ratio of 5–7 : 1.

Group 4: Pulmonary/systemic flow ratio greater than 2 : 1 and a systemic/pulmonary resistance ratio of less than 5 : 1.

Groups 5 and 6: Low pulmonary flow and high resistance. Pulmonary/systemic flow ratio of less than 2 : 1 and systemic/pulmonary resistance ratio of less than 5 : 1. Group 6 cases had reversal of flow through the defect.

Methods

The mean follow-up period was 9.5 years. One hundred forty-four children were treated surgically, but only 137 children (15.5% of the total) had complete correction. The actuarial survival curves were constructed according to the modification by Anderson et al. [1] of the method of Kaplan and Meier [8]. All the survivors were examined in the years 1989–1990. We used the functional classification criteria of the New York Heart Association (NYHA): Class I, no cardiac symptoms with ordinary activity; class II, no symptoms at rest but some limiting symptoms with ordinary activity; class III, marked limitation of physical activity; and class IV, cardiac symptoms at rest.

Results

Asymptomatic Children

Of 683 asymptomatic children (77.4%), 643 were diagnosed noninvasively and 40 (in the early years of the study) by invasive methods. All of them were in hemodynamic group 1. At the first examination only 22% of the patients were less than 1 year of age. At the end of the follow-up period, in 275 of the 683 patients (40.2%) the defect had closed spontaneously, at a mean age of 3.5 years. Twenty patients have been lost to follow-up. In the remaining patients no symptoms developed, no treatment was required, and they are in functional class I of the NYHA.

Symptomatic Children

All 199 symptomatic children (22.5%) have had at least one catheterization, and 85% were less than 1 year of age at the first examination. At the initial catheterization, 25, 65, 107, and 2 patients (12.5, 32.6, 53.7, and 1%, respectively) were in hemodynamic groups 2, 3, 4, and 5–6, respectively.

At the end of the follow-up period, the evolution of the patients is discussed below.

Group 2. Of the 25 patients in this group, the defect closed spontaneously in six (24%) at a mean age of 2.5 years. Four patients have been lost to the study; five patients are awaiting complete correction, and 10 children were corrected surgically, at a mean age of 9 years (range 6–11) years, with no mortality; after 4 years mean postsurgical follow-up they are asymptomatic, in class I of the NYHA, with no residual VSD detected, although with physical signs of slight or mild aortic regurgitation in four patients.

Group 3. Of the 65 patients in group 3, two were lost to follow-up, in 16 (24.6%) there has been spontaneous total closure or partial closure with regression to hemodynamic group 1 (demonstrated at recatheterization) at a mean age of 2.7 years, five are awaiting complete correction, and in 42 patients the complete correction was performed at a mean age of 4 years (range 6 months to 10 years) with a surgical mortality of 4.7% (two patients). After a mean postsurgical follow-up of 5.5 years of the 40 living surgically corrected patients 28 are without symptoms and without evidence of residual defects; three have physical signs of slight or mild aortic regurgitation; six have a small residual VSD and they are in hemodynamic group 1 (demonstrated at recatheterization) and are in class I of the NYHA; two required a second operation to correct a residual VSD with disappearance of the symptoms in one and the development of a complete atrioventricular block in the other, corrected by a permanent pacemaker. One child was lost to the study after complete correction.

Group 4. Of the 107 patients in this group, nine (8.4%) died of congestive heart failure and respiratory complications before it was possible to attempt surgical correction; four were lost to the study; one is waiting for complete correction; one regressed spontaneously to hemodynamic group 1 because of

Table 1. Surgical mortality rates in the closure of isolated VSD in 85 patients in hemodynamic group 4

Age (years)		1971–1982	1983–1988	1971–1988
0–2	Operative	23	11	34
	Deaths (%)	8 (34.7%)	0	8 (23.5%)
2–4	Operative	20	11	31
	Deaths (%)	2 (10%)	0	2 (6.4%)
4–8	Operative	13	7	20
	Deaths (%)	2 (15.3%)	1 (14.2%)	3 (15%)

partial closure of the defect; and 92 patients were treated surgically. Of these, seven patients were treated exclusively with palliative intervention, pulmonary artery banding, with three operative deaths, two survivors that were lost to follow-up, and the remaining two, who presented with multiple VSD-type "swiss cheese septum," regressed to hemodynamic groups 1 and 2. The complete correction was performed without previous palliative surgery in 67 patients and after banding in 18. Of these 85 patients, 13 (15.3%) died, the majority of them in the 0–2-year age group and in the period before 1983. Table 1 lists these facts and shows the drastic decrease in the mortality after 1982. The mortality rate for patients treated by banding and secondary VSD closure (16.6%) was similar to that of the patients that underwent primary repair (14.9%). However, after banding three patients died before VSD closure. Therefore, the total accumulated mortality rate of all patients treated by banding (24%) was higher than that observed with primary repair or one-stage approach (14.9%).

Of the 72 survivors, followed for a mean period of 6.5 years after the total correction, 51 are asymptomatic and without evidence of residual defects, four have been reoperated for a persistent VSD, with good results. In another 14 patients, a residual VSD has been found, but they are in hemodynamic groups 1 and 2 and in NYHA class I: reoperation appears to be unjustified. In one patient a complete atrioventricular block was treated by a permanent pacemaker. The remaining two children have developed pulmonary vascular disease: they are in hemodynamic groups 5 or 6 and in NYHA class III–IV.

Groups 5 and 6. The two patients initially in these groups were judged inoperable and, at the end of the study, were in class III and IV.

Actuarial survival curves. The curve constructed from the data on 109 children in hemodynamic groups 4–6 (Fig. 1) shows that most of the deaths occurred within the first year, with 84.1% survival

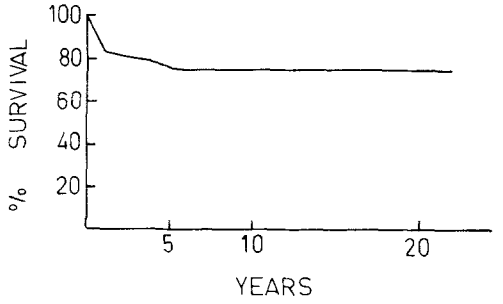

Fig. 1. Actuarial survival rates for 109 children with isolated VSD in hemodynamic groups 4–6 (systemic/pulmonary resistance ratio of less than 5/1).

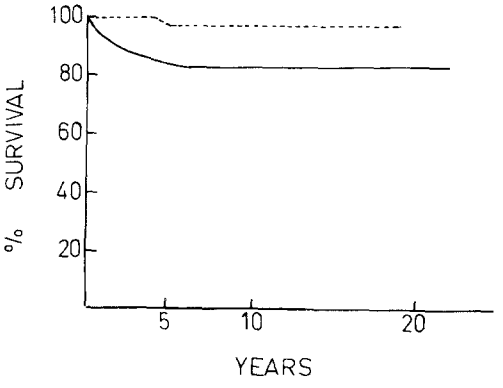

Fig. 2. Actuarial survival rates for 85 children with isolated VSD and complete surgical correction in the period 1971–1982 (*continuous line*) and of 52 children operated on in the period 1983–1988 (*dotted line*).

at the end of year 1. Afterward the curve flattens off. Survival at the end of the 5th year was 75.2%. The curves for children who underwent complete correction before and after 1983 (85 and 52 children, respectively) demonstrate the drastic improvement in outcome, with final survivals of 83.4 and 97%, respectively (Fig. 2). The difference in survival is statistically significant between the 1st and 10th years.

Aortic Regurgitation

Aortic regurgitation, confirmed by cardiac catheterization, developed in seven patients (0.7%) at a mean age of 8 years. Four patients were in hemodynamic group 2 and three patients in group 3. All underwent closure of the VSD without aortic valve surgery, because the regurgitation was slight or mild. The follow-up evaluation indicated no progression of the valvar lesion.

Infective Endocarditis

Five patients (0.5%; 0.6 per 1000 patient-years) were diagnosed clinically as having infective endocarditis. In four the diagnosis was confirmed by positive blood cultures (*Streptococcus viridans* in three and *Staphylococcus aureus* in one patient). No causative organism was identified in one patient. The age range was 4–7 years, and two patients had Down's syndrome. None of the patients died, but one patient who presented with infective endocarditis within 2 months after surgery required reoperation.

Discussion

This study has surveyed the clinical course of children with isolated VSD and the classification of patients according to their hemodynamic state. The main guidelines for the treatment of isolated VSD were set about 20 years ago, when it was established that most VSDs close spontaneously, that only about 25% of children develop symptoms in early infancy, and that some of them improve spontaneously as a consequence of a reduction in the size of the defect [2, 6, 7]. Consequently, only 15–20% were found to require surgical treatment, and further studies in the 1970s established the good results of surgery and the importance of complete repair before severe permanent changes in the pulmonary vascular bed developed [5, 12, 13]. Thus, prompt identification of those patients with the risk of pulmonary vascular disease requiring surgical treatment is essential, but this is not always easy [3, 9, 15].

The results in our hospital for a large population of patients studied over a period of 17 years reflect the fact that 77.4% of children with isolated VSD are asymptomatic because the small defects are without hemodynamic importance; the defect closed spontaneously in 40.2%. Only 22.5% of the patients were symptomatic, and only 12.3% were in hemodynamic groups 4–6 (with a systemic/pulmonary resistance ratio of less than 5 : 1) at the initial catheterization. No patient changed from hemodynamic groups 1–3 to groups 4–6.

Our results also reflect the improvement in the outcome of children with a significant defect during the period of the study, as well as the favorable outcome of complete surgical correction nowadays, particularly in less severe hemodynamic cases. They suggest that in children with large and symptomatic VSDs the surgical intervention should be carried out sooner rather than later. The cases of VSD complicated by aortic regurgitation in the course of their evolution would also support early correction, because of the risk that it may progress rapidly.

The low incidence of infective endocarditis is similar to that reported by Dickinson et al. [4], 0.5 per 1000 patient-years, and perhaps reflects a lower incidence of this complication in younger than in older patients [3, 4].

The overall mortality rate in our series is about 3%, and 13.5% for symptomatic children in hemodynamic groups 2–6, substantially better than that in the relatively old series of Keith et al. [9, 10] and Dickinson et al. [4], and similar to that in other large series [16]. About two thirds of the deaths took place between 1 month and 1 year of life, and one third of the deaths occurred before surgical treatment, in the majority before 1 year of age and mainly before 1983. We confirm here the relationship between overall mortality rate, surgical mortality rate, and hemodynamic status. Thus, no patient in groups 1 and 2 died, the mortality rate in group 3 was 3%, and in groups 4–6 about 25%. Surgical mortality rates for hemodynamic groups 2, 3, and 4 were 0, 4.7, and 15.3%, respectively.

Also to be noted is the progressive improvement in the results of complete correction, with a mortality rate of about 21% before 1983 and only 3.5% afterward. This improvement in the later period parallels the decrease in the use of banding of the pulmonary artery, which since 1983 has been used in only two patients with isolated VSD.

Our results support the view that the defect should be closed, if required, at any age by one-stage operation. As was stressed by others, in children with symptomatic large defects the complete correction should be carried out before 2 years of age [6, 16].

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