Long-term follow-up of congenital aortic stenosis after surgery

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Forty patients underwent surgery for congenital aortic stenosis between the years 1960 and 1963 at Royal Liverpool Children's Hospital. Two hospital and three late deaths occurred. An average follow-up of 7.8 years per patient is available on 35 patients. Of the survivors, 26 show no deterioration; 6 show evidence of deterioration and the reasons for this are discussed. Diastolic murmurs are present in 28 out of 33 patients. The overall mortality is 13.5 per cent for an average follow-up period of 7.8 years, i.e. an annual mortality of 1.7 per annum. It is concluded that aortic valvotomy minimizes deterioration during the second decade of life.

The management of congenital aortic stenosis continues to pose a dilemma to the clinician in view of the natural history of the disease, which has an increasing mortality with age from 1.2 per cent per annum for the first two decades (excluding the first year) to 3.0, 3.5, 6.0, and 8.5 per cent per annum in the third to sixth decades, respectively (Campbell, 1968a). Campbell also quoted the average for a series of papers (Landtman, Loukimo, and Wallgren, 1966; Edwards and Jones, 1962; Marquis and Logan, 1955; Braverman and Gibson, 1957; Ongley *et al.*, 1958), giving a figure of 1.4 per cent per annum for all deaths in children excluding early infancy. It has been shown that when the peak systolic gradient exceeds 60 mmHg or more during the first and second decades, clinical and electrocardiographic deterioration is likely to occur (Edwards and Jones, 1962). There is some evidence that this may be due to increase of gradient, but this conclusion must be regarded as tentative (Friedmann, Modlinger, and Morgan, 1971; Moller, 1971). The tendency for the stenosis to progress has been stressed by many authors, and even when the gradient is initially small the liability to develop obstruction due to increasing rigidity of the valve caused by calcific deposits remains considerable (Hohn *et al.*, 1965; Campbell, 1968b).

Aortic valve replacement during the first two decades of life is an unsatisfactory procedure in that the long-term outlook is still uncertain, though it may have to be undertaken when the valve has become irreparably

damaged. Interest centres therefore upon evaluating the effect of valvotomy, infundibulotomy, or relief of supravulvar stenosis on the natural history of the disease. Fisher, Mason, and Morrow (1970) report on 45 patients operated upon, with 4 deaths, but the age range was wide, 1.5-36 years and the follow-up time relatively short, 6 months to 5 years (average 18 months). Satisfactory relief of the obstruction was achieved except in some with outflow tract obstruction and diffuse supravulvar narrowing of the aorta. Mulder *et al.* (1968) report on 45 children with 8 deaths after operation, 2 being under 1 year of age. They emphasize the deleterious effect of aortic regurgitation after operation. They concluded that in 24 there was a good result and in 6 a fair result - a total of 66 per cent. Five were not improved, there were 8 deaths, and 2 were lost to follow-up. The group with diffuse subvalvar stenosis did particularly badly (in contrast to those with a diaphragm), and they advised a conservative approach in these subjects.

Thomson and Fisher (1965) report on the follow-up of 23 patients after valvotomy, with 1 death in a 4-week-old infant and a late death due to uncontrolled aortic regurgitation. Eight had mild aortic regurgitation, 4 moderate, and 1 severe.

In the present paper 40 patients who were operated on between 1960 and 1963 at the Royal Liverpool Children's Hospital have been followed up with a view to assessing the effect of operation.

TABLE

Gradient by LVP (mmHg)	Case No.	Sex	Age at operation (yr)	Follow-up (yr)	Final ECG		Final ECG compared to pre-op ECG (+ better, S same, - worse)	Deterioration (+) no deterioration (0)	Diastolic murmurs		Calcification of valve
					SV ₁ +RV ₆ (mm)	T waves			Pre-op	Post-op	
										Early Late	
VALVE STENOSIS (25 PATIENTS)											
50-59	12	F	13	7	41	↓	S	0	1	0	0
60-69	24	M	14	6	60	↓	-	0	0	0	0
	32	M	20	7				+	0	1	+
	37	F	4½	5	66	↑	-	0	0	1	0
	40	F	8	2	40	↓	S	+	0	3	0
70-79	2	M	8	9	36	Flat	+	0	0	1	0
	4	M	5	5	27	↑	S	0	0	1	0
	16	M	11	10	50	↑	S	0	0	1	0
	31	M	13	8	50	↑	-	0	0	1	0
	38	M	16	7	66	↓	-	+	3	2	0
80-89	10	F	9	8	39	↓	S	0	1	2	0
	19	M	7	9	25	↑	S	+	0	1	0
90-99	22	M	13	9	68	↓	-	0	2	2	0
	6	F	11	7	21	↑	+	0	0	0	0
	11	M	12	9	39	Flat	S	0	0	2	0
	25	M	7	8	72	Biphasic	-	0	0	2	0
100-109	1	F	10	—					1		
	29	F	10	9	42	Biphasic	S	0	0	2	0
	33	M	10	9	40	↓	-	0	0	1	0
	34	M	8	9	29	↓	+	0	0	2	0
110-119	28	M	6	9	35	↑	-	0	0	0	0
130-139	35	F	11	9	67	↑	-	+	0	2	0
Failed estimation	7	F	12	9	66	↓	-	0	0	2	0
	18	F	17	7	41	↑	+	0	0	1	0
	21	M	26	3	50	↓	-	0	0	1	+
VALVAR+SUBVALVE STENOSIS (5 PATIENTS)											
60-69	8	M	12	7	50	↓	-	0	0	1	0
70-79	26	M	10	5	33	↓	-	+	2	3	0
80-89	30	M	4	9	87	↓	-	0	0	2	0
110-119	13	F	14	8	40	↑	S	0	2	1	+
140-149	36	F	7	8	44	↑	-	0	1	2	0
SUPRAVALVE STENOSIS (1 PATIENT)											
100-109	3	M	7	8	41	↑	S	0	0	0	0
SUBVALVE STENOSIS (9 PATIENTS)											
50-59	15	M	12	9	46	↓	-	+	1	3	0
60-69	27	M	12	1½	35	↑	+	0	2	1	+
70-79	5	F	14								
	9	F	10	11	48	↓	-	0	0	0	0
	23	F	16	2	61	↓	-	0	0	1	0
100-109	17	M	10	7	38	↓	-	0	1	0	0
	20	M	9	9	77	↓	-	+	2	1	0
	39	M	6	8	48	↓	S	0	0	1	0
Failed estimation	14	M	13	11	32	Flat	S	0	2	2	0

Valve replacement	Deaths	Remarks
o	o	Normal pregnancy
o	o	
+		Valve calcified at operation, awaiting valve replacement Australia
o	o	
	+	4 years' post-op. LVF
o	o	
o	o	
o	o	
o	o	
+	+	CCF, late death 1 mth after fascia lata graft
o	o	
o	o	Haematuria, chronic pyelonephritis
o	o	
o	o	
o	o	
	+	Died 48 hr post-op.; pulm. oedema
o	o	
o	o	
o	o	
o	o	Bronchiectasis
o	o	Turner's syndrome
o	o	
o	o	Normal pregnancy
o	o	Valve calcified at operation
o	o	
+	o	Gross incompetence, valve replacement 1965, Starr valve
o	o	
o	o	Moderate aortic incomp.; heart catheterization; valve calcified 1971; paroxysmal tachycardia
o	o	
o	o	
o	o	
o	o	Associated persistent ductus arteriosus; pain in chest
	+	Died; lt. cerebral haemorrhage; valve calcified and stenosed; aneurysm just above valve
	+	Death at 48 hr; post-op. bleeding; no necropsy
o	o	
o	o	
o	o	
o	o	
o	o	
o	o	Pain in chest and abdomen ? gastric ulcer

Results

The ages and clinical features are shown in the Table. Subjects were regarded as having not deteriorated if they were symptom free, and there was no limitation of physical activity by excessive breathlessness. Deterioration was considered to have occurred if during the period of follow-up there was increasing breathlessness on exertion or the appearance of other features including chest pain or paroxysms of tachycardia. Haemodynamic re-evaluation was not feasible because many subjects had moved from the Liverpool area.

Thirty-four patients were followed up for 5 years or more and 30 of these for over 7 years.

Mortality There were 2 early and 3 late deaths. One early death (Case 1) within 48 hours of operation was due to pulmonary oedema, consequent upon a fault in perfusion technique. The second (Case 5) also occurred within 48 hours and was probably primarily due to postoperative haemorrhage.

One late death was at 18 months after operation (Case 27) and was due to a cerebral haemorrhage, possibly secondary to an embolus from the site of an aneurysm at the root of the aorta.

These three postoperative deaths can be disregarded from the point of view of analysis of the consequences of aortic valve surgery on the haemodynamic state. This leaves two deaths at 4 and 7 years after operation (Cases 38 and 40). In the first, aortic regurgitation was marked before operation and in retrospect valvotomy was contraindicated. The regurgitation became worse after valvotomy, the heart size increased, the electrocardiogram deteriorated, and 7 years after the initial operation he had a valve replacement in Australia but never regained consciousness. The second patient developed grade 3/4 aortic regurgitation, and again there was increase in heart size and electrocardiographic deterioration. She died at home after a short illness very suggestive of left ventricular failure with pulmonary oedema.

Follow-up on 35 patients Omitting the 2 early deaths and 3 others on whom no follow-up data were available, 35 patients were followed for 272 patients years, an average of 7.8 years per patient. This gives an annual mortality of 1.1 per cent per year.

If one omits the three late deaths, the remaining 32 may be divided into 26 who did not deteriorate according to the criteria defined above and 6 who did. Analysis of the

6 showing deterioration is included in the Table, as are also 2 of the late deaths (Cases 38 and 40). Of these 6 patients, 3 had another lesion: a large persistent ductus ligated before valvotomy, pyelonephritis, and bronchiectasis, respectively. The preoperative peak systolic gradients varied from 55 to 130 mmHg, a mean of 84.2 mmHg compared with 55 to 140 mmHg for the group without deterioration. Aortic regurgitation was a conspicuous feature in one subject (Case 26) and required insertion of a Starr-Edwards valve 5 years after the first operation. There was also evidence at reassessment of subvalvar obstruction. If one calculates the mean value for the grade of regurgitation in these 6 subjects, it is 1.7, which compares with 1.5 for the group without deterioration. Regurgitation was probably only of importance in Case 26.

In Cases 20, 26, 32, and 35 residual obstruction appears to have been the primary reason for deterioration. In Case 35 there was radiological evidence of calcification of the valve. Case 32 is awaiting valve replacement elsewhere, and when last seen he had no evidence of regurgitation, so that obstruction seems probable. In all four patients there is clinical and electrocardiographic evidence of left ventricular hypertrophy and obvious inversion of the 'T' waves.

26 patients without deterioration These are characterized by absence of the various features that have just been described in the 6 who deteriorated and the 2 late deaths. If the 3 without follow-up information are omitted, but all deaths included, there are 37 patients of whom 26 did well (70%). The overall mortality is 13.5 per cent for a follow-up period of 7.8 years, which gives an annual mortality of 1.7 per cent per annum.

Discussion

Aortic valve obstruction is due to two factors: commissural adhesion and stiffening of the valve cusps due to deposition of calcium. During the first and second decades commissural adhesion is almost certainly the main factor, the cusps being nearly always mobile, as indicated by the well-marked ejection click. Campbell (1968b) has shown clearly in his series of 69 cases that the second factor, calcification, advances steadily with age. The incidence of calcification was zero in the first decade, 1 out of 15 in the second and 4 out of 10 in the third decade. Nevertheless, calcification may start during childhood, and was present at the first operation in 2 of our patients aged 20 and 26 years. Increasing

stiffness due to deposition of calcium is likely to be the main factor that increases the gradient across the valve. If this were important and common during childhood there would be no place for valvotomy. There is considerable evidence, however, that this is not the case. Effective relief of obstruction has been well shown (Mulder *et al.*, 1968; Fisher *et al.*, 1970; Ellis, Ongley, and Kirklin, 1962; Morrow, Goldblatt, and Braunwald, 1963; Cooley *et al.*, 1965). From the surgeon's point of view the crucial question is how much he should do to the valve. In the present series both residual obstruction and excessive regurgitation were responsible for deterioration. Similar problems have been reported in other series (Fisher *et al.*, 1970; Mulder *et al.*, 1968).

Only 5 out of 33 patients in our series were entirely without diastolic murmurs due to regurgitation, and in 2 of the late deaths and 1 of the 6 who deteriorated, this regurgitation was considered to be an important factor. Though residual obstruction has not been assessed, on the evidence presented it appears likely to have contributed to deterioration in 4 out of the 6. Doubtless there was also residual obstruction in the 26 who did not deteriorate, but it seems probable that the overall results would have been made worse rather than better by a more radical valvotomy. The other factors that contributed to deterioration were associated disease and age. The 2 oldest patients of the 6, aged 16 and 20 years, did badly – one because of regurgitation and the other because of residual obstruction.

Omitting the 2 early deaths due to faulty operative technique there were 3 deaths among 35 patients followed for an average of 7.8 years. This gives a mortality of 1.1 per cent per annum which compares favourably with Landtman *et al.*'s series (1966) and the composite figure of 1.4 per cent given by Campbell (1968a). If one includes all the deaths, the annual mortality becomes 1.7 per cent. Since the present series is a selected group of more severe lesions with gradients over 60 mmHg, this series provides evidence to support the view that the current policy for operative treatment, while by no means perfect, does minimize deterioration during the second decade.

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Notice

International Study Group for Research in Cardiac Metabolism

The 5th Annual Meeting of the International Study Group for Research in Cardiac Metabolism will be held in Winnipeg, Canada, during 27 to 30 June 1972. Three symposia, namely: myocardial hypertrophy, newer aspects of myocardial metabolism, and regulation of calcium in the heart have been organized. In addition, a special programme on recent advances in heart biology and nine general sessions for free communication have been arranged. The last date for the receipt of abstracts and advance registration is 15 April 1972. For further information please write to: Dr. N. S. Dhalla, Department of Physiology, Faculty of Medicine, University of Manitoba, Winnipeg 3, Canada.