Aortic Valvular Surgery with Artificial Valves

An Analysis of the First 100 Patients

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TWO AND A HALF years have now elapsed since we performed our first successful prosthetic replacement for severe aortic regurgitation. During this time, 115 patients with severe aortic regurgitation and/or calcific stenosis have had operative correction by means of artificial valves. This presentation is a review of the patients who presented themselves for operation, the surgical management, and the results. An analysis of the preoperative status of 58 patients with pure aortic regurgitation and 28 patients with calcific stenosis who had valvular replacement was made to clarify operative indication and patient-selection in the future. Patients with more than one valve involved, or in whom the preoperative findings were incomplete, were eliminated from this analysis. The status of 40 patients followed from 6 to 30 months after operation was evaluated for comparison with their preoperative condition.

Aortic Regurgitation

Thirty-six, or 66 per cent, of the patients had histories of rheumatic fever as children, with an average age of 11 years at the time of the first attack. All of the patients had known of the existence of cardiac murmurs from examinations made 5 to 15 years previously. During this period, they were essentially asymptomatic; but during this asymptomatic period, serial roentgenograms showed increasing degrees of cardiomegaly.

The average age at the time of operation of patients with aortic regurgitation was 30 years, with a range from 10 to 55 years. Seventy-four per cent were men; all but three were symptomatic. These three patients had severe cardiomegaly with, respectively, 25 per cent, 40 per cent, and 63 per cent cardiac enlargement.

At the time of the cardiac evaluation preparatory to operative correction, symptoms of cardiac disease had been present for an average of 15 months. Although palpitation was usually the first complaint noted in 23 (42 per cent), dyspnea on exertion was the most common finding (44 patients—80 per cent). Twenty-two patients (40 per cent) had angina; 17 of them had electrocardiographic evidence of myocardial ischemia. All had evidence of left ventricular strain. Twenty-five (45 per cent) were either in congestive failure or had been prior to admission. Of these, 19 (35 per cent) of the entire group had elevated left ventricular end-diastolic pressures at the time of their cardiac evaluations. These patients ranged from 13 to 53 years of age, with the majority in the third decade of life. Only three patients had evidence of atrial fibrillation. Each of these either was or had been in congestive failure and had elevated left ventricular end-diastolic pressure. All patients but one had roentgenographic evidence of cardiac enlargement demonstrated by cardio-thoracic ratio, volume studies, and Ungeleider's determination. Thirty-nine patients (72 per cent) had 25 per cent or greater cardiac enlargement. Only 5 (9 per cent) had 15 per cent or less cardiac enlargement. In one patient with normal cardiac size, there was a four-plus regurgitation, and he had severe angina. The average cardiac volume by the technique of Kjellberg and Rudhe was 1,229 ml. The normal cardiac volume in adults at this hospital by this technique was 650 ml.

There is a scarcity of information on survival rates of medically followed patients with aortic regurgitation. It would appear from
available material\(^1\) that the life expectancy of patients with severe aortic regurgitation is considerably foreshortened, with few living beyond 50 years of age, and that the peak mortality rate occurs somewhere between 30 and 40 years of age. It would appear from this analysis that hemodynamically significant aortic regurgitation may cause progressive myocardial deterioration during the asymptomatic stage. It would also appear that myocardial failure is usually preceded by some forewarning symptoms, even though mild in character, to alert the patients and their physicians to impending danger. Evidence of increase in cardiac size or change in the electrocardiogram pattern indicates the need for further physiological studies to ascertain the degree of severity.

**Calcific Stenosis**

Only 9 of the 28 patients had histories of rheumatic fever during childhood, with an average age at onset of 14 years. They had had known cardiac disease from 3 to 20 years, but symptoms had been evident for an average of only 18 months at the time of their preoperative evaluations. The duration of their symptoms ranged from three months to four years. All of the patients were symptomatic.

The average age at the time of operative correction was 49 years, with 17 (68 per cent) aged 45 years or older. Twenty-five patients (88 per cent) were men.

Dyspnea was the most common symptom, noted in 80 per cent of the patients. Eleven (44 per cent) had angina, 52 per cent had syncope, 8 (32 per cent) had been in congestive failure, and 6 (24 per cent) had evidence of atrial fibrillation.

**Cardiac Size**

All of the patients had evidence of cardiac enlargement by roentgenographic studies. Sixty-one per cent (17 patients) had over 25 per cent enlargement. There was an average cardiac volume of 1,039 ml.

**Hemodynamic Findings**

There was an average gradient over the aortic valve of 90 mm. Hg. Fourteen patients (50 per cent) had elevated left ventricular end-diastolic pressures (over 12 mm. Hg). These same patients had elevated pulmonary artery and pulmonary capillary wedge pressures at rest, indicative of left ventricular failure. In addition, all of the patients had elevated pulmonary arterial and pulmonary capillary pressures with exercise, indicative of the inability of the left ventricle to eject blood through the stenosed aortic orifice with increased demand.

**Electrocardiograms**

All of the patients had evidence of left ventricular strain. Six patients (24 per cent) had atrial fibrillation. Sixteen (57 per cent) had evidence of myocardial ischemia. This latter finding presents a difficult problem, in that it is known that patients with associated coronary arterial disease have a higher operative risk and mortality rate.

It has been difficult or impossible to assess the role of relative coronary insufficiency and organic coronary sclerosis in the evaluation of the electrocardiographic findings of patients with calcific aortic stenosis, or even to know whether in any given individual there is superimposed coronary arterial disease.

**Operative Mortality Rate**

There was an operative mortality rate within the first 30 days of 14 per cent in patients with aortic regurgitation and 19 per cent in calcific stenosis. Many of the factors responsible for this operative mortality rate have been corrected, so that in the future it should be materially reduced. There were 13 deaths in the first 75 patients who underwent operation. There were 22 factors relating to the heart, the myocardial protection, and the extracorporeal perfusion which were responsible for these deaths. Twenty-two, or 30 per cent, of the 75 patients were in left ventricular failure at the time of the operative procedure. Eight, or 36 per cent, of these patients died postoperatively. Twenty-one patients had prolonged hypothermic perfusion at flow rates subsequently found to be borderline, even though theoretically the oxygen requirements at the level of hypothermia employed (25 C.)
should have been adequate. Nine of these patients (43 per cent) died of complications felt to be due to hypoxia. This potential complication was recognized and corrected.

When it became apparent from analysis of perfusion data that inadequate flows had been responsible for complications and death due to hypoxia in the above patients, flow rates of not less than 40 ml./Kg./min. were subsequently employed. No deaths resulted from hypoxia in the last 40 patients with this flow rate. In this latter group, there were six factors that contributed to four deaths. Associated coronary arterial disease with obstruction and left ventricular failure again constituted the main factors in mortality. Even though there was a higher incidence of patients in left ventricular failure in this latter group (19 of the 40 patients, or 47 per cent), only 4 (21 per cent) died postoperatively, in contrast with 8 of 22 patients (36 per cent) of the initial group of 75 patients. This indicates that, although a higher incidence of poor-risk patients was being operated upon, greater experience in their operative and postoperative management resulted in greater success. In this latter group, operative mortality due to technical difficulties accounted for only one death (an incidence of 3 per cent). The other deaths were due to factors beyond the control of the surgeon.

Operative Results

It is too soon to form an opinion about late results of operative correction of aortic valvular disease with artificial valves; nevertheless, the status of 40 patients 6 to 30 months after operation is presented. The benefit so far attained by prosthetic replacement is far superior to that attained by any previous technique.

Evaluation

Symptoms

Symptoms have completely disappeared in the regurgitant group, except for two patients in whom there is evidence of some remaining regurgitation. These two patients are improved, but some tachycardia and occasional palpitation are still noted. The other 38 are completely rehabilitated and have resumed normal activity.

Electrocardiogram

Little change was noted in the first six months to a year in the electrocardiographic findings. However, at the end of two years, definite improvement was noted in the left ventricular strain pattern, and in some patients this has completely disappeared. Greater improvement was noted, for the most part, in the younger group of patients, as well as in those who did not have ventricular failure. Too few patients have reached the two-year evaluation period to be of statistical significance in presenting the number and degree of improvement.

Cardiac Size

There was a greater reduction in cardiac size in patients with aortic regurgitation than in patients with stenosis. The greatest reduction in cardiac size in patients with aortic regurgitation took place in the immediate postoperative period, with a further gradual reduction over a two-year period. There was an average reduction of 2 cm. in the transverse diameter of the heart in patients with aortic regurgitation, and of 1 cm. in patients with calcific stenosis. The major factor in reduction in cardiac size is probably the disappearance of the element of cardiac dilatation, in that reduction in myocardial mass must necessarily be a slower process and probably will persist to some degree. There was an average reduction in cardiac volume of 220 cc. Too few patients have reached the two-year evaluation period to be of statistical value. No heart has returned to completely normal size. The reduction in cardiac size has paralleled quite closely the improvement noted electrocardiographically.

Auscultation

Auscultation, as well as phonocardiographic examination, revealed a slight systolic murmur in the majority of patients, but a diastolic murmur in only two patients. This slight systolic murmur was noted in such instances immediately postoperatively and did not change over the ensuing months. This is felt to be due
to eddies of current produced by the hypertrophied left ventricular outflow tract.

**Hemodynamics**

As yet we have not routinely obtained angiographic and left ventricular studies on all patients postoperatively, feeling quite content in the majority of cases to rely on symptomatic, physical, roentgenographic, and electrocardiographic findings as indices of improvement. A number of cineangiograms and left ventricular studies have been taken over a two-year period in an attempt to determine more precisely what is happening to the artificial valve. These indicate that the valve continues to function properly during this period of time and that no stenosing factor is encountered up to at least a two and a half year period.

**Complications**

In the entire group of 115 patients with artificial valvular replacement, there was no evidence of an adverse effect upon the blood components, of increased hemolysis, or of anemia. One patient developed fibrin accumulation which caused coronary occlusion. There were no other instances of undue fibrin deposition or clotting. One patient developed subacute bacterial endocarditis approximately 10 months postoperatively, after a lung infection. There was one other possible instance of such an infection developing two months postoperatively, although it was never proved. Since such a complication may exist, precautionary measures should be taken. One patient restenosed the valve at the site of fixation of the artificial valve to the remnants of a previously thickened, stenosed valve. Nine patients had failure of permanent fixation with partial detachment; this will be discussed later in the report. Changes in design of the valve and in the technique of fixation have almost completely eliminated this complication.

**Fate of the Artificial Valve**

Obviously, a period of two years is much too short a time in which to arrive at any conclusions as to the fate of the artificial valve; however, evidence accumulated during this period indicates that some of the initial concern about using a plastic valve was unfounded. Experimentally, it appeared that fibrin accumulation and clot formation would lead to early stenosis and possible embolization. Clinically, this has not been a problem. The criticism that the heart would not tolerate a foreign body has been unwarranted. Similarly, the fear that the leaflets of the artificial valve would stiffen and not function normally has not been borne out—at least in this two and one-half year period. All evidence indicates that flexibility persists. Permanency of fixation was a problem in the first 55 patients, in that there were seven recurrences from partial detachment of the valve at the site of commissural attachment. Changes in design of the valve have corrected this complication so that this has been a factor in only two instances in the last 60 patients. A three-leaflet valve is made from porous Teflon knitted fabric, which is filmed with polyurethane. This prevents fibrin accumulation. Patients are heparinized postoperatively and kept on Coumadin for one year as a precaution. The edge of the artificial valve to be attached to the aortic annulus is left free of polyurethane to allow tissue ingrowth into the porosity of the plastic fabric for permanency of fixation.

Commissural detachment was found to be responsible for recurrence of regurgitation in 7 of the first 55 patients. To obviate this, the design of the valve was changed so that commissural detachment was impossible. Extensions of the valve-leaflet were fashioned into cords which were passed through the aortic wall and secured with the corresponding extension from the adjacent leaflet over pledgets of Teflon felt. There have been only two partial detachments during the past 12 months in 60 patients in whom this design was used. These two recurrences were in patients with extensive calcific stenosis as a result of failure of complete healing by tissue fixation within the depths of the sinus of Valsalva at the site of the previous calcification. To obviate this possibility, the valve now used in such instances has cords, similar to those at the com-
missure, extending from the base of the valve. These cords are passed through the aorta and secured in a similar manner to the others outside the aortic wall, so that permanency of fixation in this area is secure and not entirely dependent upon internal healing.

Summary

An attempt has been made to present a profile of patients with aortic valvular disease who presented themselves for operative correction, and to demonstrate the effectiveness of prosthetic replacement in the surgical treatment. Experience to date, in 115 patients so treated, demonstrates the effectiveness of this technique. The operative mortality due to technical factors has been low, and the clinical results have been excellent. Since the operative mortality now occurs primarily in those patients with myocardial failure, its prevention, if possible, is advisable by earlier detection and surgical correction.

Reference

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