Advantages of the Beall Valve Prosthesis*

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Followup of 29 patients with a Beall mitral valve prosthesis has shown important advantages over the Kay-Shiley valve. No late deaths and no emboli were noted during an average 14 month (range 8 to 27 months) followup. Mitral insufficiency was not noted clinically or by angiography. Hemodynamic studies in nine patients 16 months postoperation showed improvement. Although all patients had evidence of prosthetic obstruction postoperatively, particularly during exercise, good symptomatic improvement, lack of emboli and preservation of disc motion, reflect advantages of this valve over others.

Although most patients who have received a disc mitral valve have been improved symptomatically, both short- and longerterm hemodynamic studies have revealed persistent hemodynamic abnormalities. Exercise studies performed one year after operation in patients with a Kay-Shiley disc valve have shown an abnormally low cardiac output and moderate gradients.1 Similar observations have been noted in short-term followup studies of patients with a Beall mitral valve prosthesis.2 However, because there have been few embolic episodes in patients with Beall valves, we have utilized Beall mitral valve prostheses for the past two years. Forty-four patients have undergone single valve replacement with five early deaths and 12 patients have undergone multiple valve replacements with four early deaths. No late deaths have occurred. This paper presents long-term followup observations in 29 patients observed an average of 14 months (range 8 to 27 months). All patients were catheterized before operation and nine were recatheterized an average of 16 months after operation (range 10-20 months).

METHODS

Twenty-nine patients have been observed since discharge from the hospital. There were 17 women and 12 men ranging from the Cardiovascular Laboratory, Division of Cardiology, Departments of Medicine and Surgery, University of Colorado Medical Center, and Veterans Administration Hospital, Denver, Colorado. Supported in part by Clinical Research Center Grant FR 00051 and US Public Health Service Grant 5-T01-HE 05390.

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in age from 12 to 60 years of age. Twenty patients were in class 4 and nine in class 3. Six patients had previously undergone mitral commissurotomy. The lesions were: mitral stenosis in 13, combined mitral stenosis and insufficiency in six, mid insufficiency in one, mitral and tricuspid insufficiency in nine and aortic stenosis in seven.

The valves were inserted with interrupted sutures of 2-0 Tevdek. Seven patients had two valves replaced: four Starr-Edwards aortic valves, two Starr-Edwards tricuspid valves and one Beall tricuspid. Anticoagulation with warfarin (Coumadin) was started after the chest tubes were removed and the prothrombin time was reduced to 20 to 25 percent of normal. Repeat hemodynamic studies were obtained in nine patients at an average interval of 16 months after operation. Screening tests to detect the presence of hemolysis were performed at the time of the second catheterization.

There have been no deaths in the 29 patients following discharge from the hospital, over an average interval of 14 months. All patients (except two) have experienced symptomatic improvement with 23 moving into class 2, and four into class 3.

**Hemodynamic Studies**

Nine patients underwent repeat cardiac catheterization between 10 and 20 months after operation. Average mean pulmonary arterial pressure decreased from a preoperative value of 47 mmHg to 26 after operation, pulmonary arterial wedge pressure from 26 to 13 and the mean mitral diastolic gradient from 20 to 6. During exercise, an abnormal response was seen in each of these values with the average mean pulmonary arterial pressure rising to 52 mmHg from a control of 26, wedge pressure from 13 to 28, and the mean mitral "prosthetic"
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FIGURE 3. Same patient as Figure 2. With normal diastolic interval, disc is open.

diastolic gradient to 15 from 6. In one patient, left ventricular end-diastolic pressure was abnormally elevated after operation to 14 mmHg compared to seven preoperatively, and in two patients abnormal rises to 18 and 19 were noted with exercise.

The average pulmonary arteriovenous oxygen difference decreased from a preoperative value of 6.41 vol percent to 4.78 postoperatively and the average cardiac index rose from a preoperative value of 1.86 L/min/M² to 2.62 after operation. With exercise, an abnormal response was noted in four patients as indicated by an excessive widening of the A-V difference of more than 2 vol percent for each 100 ml increase in oxygen uptake per M², compared with 1.48 vol percent in 16 normal subjects of similar ages who performed mild exercise. However, in three patients in whom the exercise response was abnormal prior to valve replacement, exercise response was now normal. Total pulmonary resistance fell in all patients from an average preoperative value of 2146 dyne-M² to 808 after operation, and pulmonary vascular resistance fell from a preoperative value of 940 dyne-M² to 390 after operation. During exercise most patients showed an increase in pulmonary vascular resistance.

Left ventricular biplane 35 mm cineangiography was performed in seven of the nine patients. None demonstrated abnormal mitral insufficiency, although in each subject a small "closure" puff was noted as dye floated above the disc during diastole and was then pushed into the atrium by the disc during ventricular systole. A poorly contracting myocardium was noted in the patient with an elevated left ventricular end-diastolic pressure. In one patient studied early, five months after surgery, a trace of abnormal mitral regurgitation was noted, perhaps at the suture line, as the disc moved normally. No murmur was heard. Disc motion was analyzed in 18 patients with 35 mm film at 60 frames per second in the right anterior oblique position. In nine patients, the disc moved smoothly and evenly during regular cardiac rhythm, as well as when ectopic beats were induced. In the remaining nine patients intermittent unevenness was noted during opening or closing of the disc. In two,

FIGURE 4. Same patient as Figure 1. Thirty-five mm frame showing partial opening of disc with downward movement being interrupted by premature ventricular beat occurring 385 sec after preceding QRS. Note LV pressure has not decreased to zero.

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Disc opens normally with slightly later premature beat occurring .399 sec after preceding QRS. LV pressure has fallen to zero. Cocking was only apparent during ventricular premature beats. In two other patients, cocking was apparent at 16 and 12 months, having been absent at five and seven months. None of the patients with cocking has significant murmurs and valve sounds are normal. All patients have full excursion of the disc. The average times required for the disc to open or close were similar, and averaged approximately one and one-half frames, 25 milliseconds. By means of the cine trace it was possible to relate disc motion to the QRS complex and hemodynamic events. A consistent observation was that whenever an ectopic beat occurred within 22 frames (.367 sec, heart rate 164) or sooner in relation to the preceding QRS, the disc did not open (Fig 1-3). Left ventricular pressure during these intervals, as recorded on the cine trace, had not fallen to left atrial levels. Failure of the disc to open usually corresponded with an ectopic beat occurring during the apex or latter part of the "T" wave. Whenever an ectopic beat occurred 24 (.40 sec) or more frames following the preceding QRS (a heart rate of 150) the disc moved the full length of the cage (Fig 4-5). Coronary arteriography did not reveal significant obstructions in any subject.

Complications

There has been no evidence of restenosis and the valve sounds have remained excellent in all patients. No significant embolization has been noted in any of the patients, although one subject experienced a two minute episode of left hemiparesis three months following discharge. All patients received anticoagulants, but fewer than half were judged to have been well controlled. Evidence of mild hemolysis has been noted in most patients as indicated by trivial to 1+ urinary hemosiderin, slight elevation of plasma Hgb and LDH, and decreased haptoglobin. However, in only three patients was the hematocrit significantly lower than before surgery and in two, a Starr-Edwards aortic valve was also present. No significant change in average hematocrit had occurred (Table 2). In no patient has hemolysis required valve replacement.

Discussion

The long-term hemodynamic findings in this study are similar to those we previously reported in patients with Kay-Shiley mitral valve prostheses. The reasons for the impaired response to exercise in some of the patients is not entirely clear. Delayed ventricular filling at rapid heart rates due to limited disc motion may have limited output in some patients, and in two patients left ventricular dysfunction may have played a role. However, in three patients, the exercise response has normalized following valve replacement suggesting that obstruction was important in limiting exercise response in those patients before surgery. It may be that the elevated end-diastolic pressure and poorly contractile left ventricle, observed in one of our patients, is a consequence of endocardial fibrosis. The fall in pulmonary vascular resistance postoperatively confirms the reversibility of elevated vascular resistance, which has been reported previously.4

Perhaps most striking is the absence of significant thromboembolic phenomenon in our subjects, followed for an average of 14 months since surgery (range of 8 to 27 months). Although warfarin (Coumadin) has been employed routinely, it should

Table 2—Beall Valve Replacement

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<tr>
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<th>Preop</th>
<th>Postop</th>
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<tr>
<td>Hematocrit</td>
<td>41%</td>
<td>40 (30 - 47)%</td>
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<tr>
<td>Retic count</td>
<td>2.4</td>
<td>(1.2 - 4.4)%</td>
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be noted that dosage has been poorly controlled in at least one-half of the patients. These findings are in striking contrast to our experience with the Kay-Shiley disc valve prosthesis. Thus, in 21 patients with isolated mitral replacement with a Kay-Shiley disc prosthesis, 1 embolism occurred in 38 percent, sometimes as long as two years after surgery, an incidence of thromboembolic complications which was similar to that reported for earlier models of ball valve prostheses. Moreover, in six patients with Kay-Shiley valves, disc malfunction has necessitated surgical replacement or resulted in death. Valves more extensively covered with cloth seem to cause fewer emboli. 6 Severe stenosis with cocking of the disc has been noted, also, in the Edwards disc valve prosthesis. Significant cocking of the valve with insufficiency or stenosis has not been noted in our patients. The hemodynamic findings, as with our previous experience, indicate abnormal gradients and low cardiac output during exercise. However, in spite of the persistence of hemodynamic abnormalities, uniformly good to excellent improvement has been noted symptomatically. Of importance is the behavior of the disc with rapid rates. Thus, with single ectopics occurring at a rate over 160/min, the disc did not open. Obviously the disc must open with sustained rates of 160, but probably only partially, and as a consequence of rising left atrial pressure. It is clear that the limitations of disc movement with increasingly fast rates can result in progressively larger "gradients" across the valve.

Clearly, serial clinical and x-ray evaluation of disc motion is required in the routine evaluation of patients following valve replacement. Although disc malfunction has not been observed in our patients with Beall valves, past experience with other disc valves emphasizes the importance of a heightened awareness and anticipation of the potential disasters consequent to abnormal disc motion, ie, severe stenosis and/or insufficiency, in management of these patients. Intermittent acute pulmonary congestion should immediately suggest a "sticky disc syndrome."1-8

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Through Revenge to Fame

Bedrich Smetana (1824-1884) returned to Prague in 1863 where he soon began to play a prominent part in the cultural revival which had been set in motion in 1860. His name became closely associated with Czech musical organizations. He even composed a Czech opera, The Brandenburgers in Bohemia. After many frustrating delays it was eventually produced on January 5, 1866. The libretto appealed to Czech patriotism, but the music could only be regarded as an attempt to emulate early Wagner. Annoyed by the comparatively poor reception given to his first opera, Smetana, who, let it be admitted right away, was a hypersensitive, ill-tempered fellow, tried to revenge himself on the good people of Prague by dashing off an operetta, a "trivial" affair which he thought only boors would be likely to appreciate. "I composed it without ambition, straight off the reel in a way that beats Offenbach himself hollow." The Bartered Bride showed him in a much more favorable light than any of his previous works. Here was jolly folk-style, music that the Czech people understood and loved. It needed three subsequent revisions before its status was raised from a two-act operetta to that of a three-act opera which ranks as a masterpiece.

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