32. Oparil S, Koerner T, O'Donoghue JK: Mechanism of angiotensin I converting enzyme inhibition by SQ 20,881 (Glu-Trp-Pro-Arg-Pro-Gln, Ile-Pro-Pro) in vivo. Further evidence for extrapolmonary conversion. Hypertension 1: 13, 1979

Thrombosed Björk-Shiley Mitral Prostheses

H. COPANS, M.B., J. B. LAKIER, M.D., R. H. KINSLEY, M.B.,
P. R. COLSEN, M.D., V. U. FRITZ, M.B., AND J. B. BARLOW, M.D.

SUMMARY During a 4.5-year period ending in January 1978, 224 patients were discharged from the hospital after Björk-Shiley mitral valve replacement. Follow-up records for all patients were available until the last date of inquiry on March 31, 1978.

Twelve patients presented to us 3–43 months (mean 17 months) after surgery with thrombosis of their mitral prostheses. A clinical syndrome consisting of acute onset of ischemic or pleuritic chest pain, dyspnea and right-sided cardiac failure is described. The prosthetic sounds, especially the opening click, are invariably absent or markedly muffled, but definitely abnormal mitral murmurs are infrequently detected. The echocardiogram is a useful adjunct in confirming the diagnosis. Total thrombotic encapsulation of the prosthesis may supervene within hours or days and is invariably fatal unless there is surgical intervention. Our first patient died because we failed to make an immediate correct diagnosis. Thereafter, the early recognition of the clinical features resulted in successful valve replacement.

In addition to the first patient, there were 18 deaths among the 224 patients. Although none of these 18 patients was examined by us, hospital records, telephone inquiries or necropsy reports revealed that six of them died because of thrombotic occlusion of their mitral prostheses.

We conclude that poor anticoagulant control was the principal factor predisposing to prothrombotic thrombosis in our experience. Eighteen patients (8%) sustained this complication during the study. Neither the original mitral valve lesion nor the size of the Björk-Shiley prosthesis was relevant. We have discontinued using the Björk-Shiley prosthesis for mitral valve replacement when we cannot be certain of ideal control of anticoagulant therapy.

THE FIRST SUCCESSFUL mitral valve replacement with a rigid component prosthesis was performed by Starr in 1960 using a caged-ball valve. Because of the problems with that prosthesis, which included hemodynamic limitations,4,3 thromboembolic complications,4 hemolysis5 and ball variance,6 numerous other valves have been designed. The Björk-Shiley tilting disc valve has frequently been used in both the aortic and mitral positions. Because of its low profile, it is particularly suitable for mitral valve replacement. The hemodynamics of the valve have been well studied7 and although normal flow characteristics are not attained, pressure differences across the prosthesis are acceptable with the larger sizes.8 In our clinical experience, the prosthesis is hemodynamically very satisfactory. The occurrence of thromboembolic complications is a serious event with any prosthetic valve, and the Björk-Shiley prosthesis is no exception.7–17

This report documents the clinical features of 12 patients in whom thrombotic occlusion of the Björk-Shiley mitral prosthesis supervened. A characteristic clinical syndrome is described, the early recognition of which should markedly reduce the otherwise extremely high mortality. The causes of death of other patients not examined by us but who had also originally survived Björk-Shiley mitral valve replacement are briefly discussed.

Materials and Methods

From June 1973 to January 1978, it was our policy at the Johannesburg Hospital to use the Björk-Shiley prosthesis for mitral valve replacement. During this period a total of 224 white patients were discharged from hospital after Björk-Shiley mitral valve replacement. Follow-up data for 100% of these hospital survivors were obtained until the study was closed on March 31, 1978. At that time 19 patients had died, one

From the Cardiovascular Research Unit, Departments of Medicine and Cardiothoracic Surgery, University of the Witwatersrand and Johannesburg Hospital, Johannesburg, South Africa. Address for correspondence: Professor J.B. Barlow, Cardiac Unit, Johannesburg Hospital, Johannesburg, 2000, South Africa. Received November 30, 1978; revision accepted July 26, 1979. Circulation 61, No. 1, 1980.
of whom was examined by us and is the first of the 12 patients in this series of thrombosed Björk-Shiley mitral prostheses. Information on the other 18 deaths was obtained from the records of this and other hospitals, necropsy reports and telephone conversations with physicians or relatives.

As large a prosthesis as possible was invariably inserted; 38% of the 224 patients received a 27-mm and 35% a 29-mm prosthesis. Of the other patients, 25-mm or 31-mm prostheses were used in 9% and 18%, respectively. Twenty-five percent of patients had a simultaneous aortic valve replacement with Björk-Shiley prostheses. Tight mitral stenosis was the commonest lesion and was encountered in 36% of instances. There was mixed mitral valve disease in 34% and pure or dominant mitral regurgitation in 30%.

The mitral valve pathology was nonrheumatic in approximately half of the latter group and comprised cases of infective endocarditis, papillary muscle dysfunction, idiopathic rupture of chordae tendineae and the floppy valve syndrome.

Of the 12 patients presenting to us with thrombotic occlusion of the mitral prosthesis, seven had had tight mitral stenosis and five mixed mitral valve disease (table 1). There were eight females and four males, ages 28–57 years. All were evaluated clinically (including an ECG and chest roentgenogram) by at least one of us and the majority were examined by two or more. Mitral valve replacement had been undertaken 3–43 months (mean 17 months) previously. In all instances the major valve orifice had been placed posteriorly, as recommended by Björk.

Three of the

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age (years)/sex</th>
<th>Previous lesion</th>
<th>Prosthesis (size in mm)</th>
<th>Months since operation</th>
<th>Presenting symptoms</th>
<th>Prosthetic mitral valve sounds</th>
<th>TISM</th>
<th>Apical MDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50/F</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (27)</td>
<td>11</td>
<td>Acute dyspnea 3 days, central substernal pain and right subscapular pain</td>
<td>Present and &quot;normal&quot; (see text)</td>
<td>2-3/6</td>
<td>Absent</td>
</tr>
<tr>
<td>2</td>
<td>36/M</td>
<td>Mixed mitral valve disease; aortic regurgitation</td>
<td>MBS (27), ABS (23)</td>
<td>11</td>
<td>Acute dyspnea 2 days, substernal pain</td>
<td>Absent</td>
<td>1/6</td>
<td>Absent</td>
</tr>
<tr>
<td>3</td>
<td>57/M</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (29)</td>
<td>8</td>
<td>Acute dyspnea 2 days, left subscapular pain</td>
<td>Muffled</td>
<td>1/6</td>
<td>Long</td>
</tr>
<tr>
<td>4</td>
<td>31/M</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (27)</td>
<td>21</td>
<td>Acute dyspnea 1 day, central substernal pain and right subscapular pain</td>
<td>Muffled</td>
<td>2/6</td>
<td>Short</td>
</tr>
<tr>
<td>5</td>
<td>41/M</td>
<td>Mixed mitral valve disease</td>
<td>MBS (27), ABS (25)</td>
<td>18</td>
<td>Acute dyspnea 3 days, short episodes of substernal pain and left anterior chest pain</td>
<td>Absent</td>
<td>2/6</td>
<td>Short</td>
</tr>
<tr>
<td>6</td>
<td>28/F</td>
<td>Mixed mitral valve disease</td>
<td>MBS (27)</td>
<td>6</td>
<td>Acute dyspnea 1 day, substernal chest pain</td>
<td>Absent</td>
<td>4/6</td>
<td>Absent</td>
</tr>
<tr>
<td>7</td>
<td>48/F</td>
<td>Mixed mitral and aortic valve disease</td>
<td>MBS (25), ABS (21)</td>
<td>32</td>
<td>Acute dyspnea and orthopnea 3 days</td>
<td>Varied; absent intermittently</td>
<td>1/6</td>
<td>Intermittent/short</td>
</tr>
<tr>
<td>8</td>
<td>41/F</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (29)</td>
<td>12</td>
<td>Acute dyspnea and orthopnea 2 days</td>
<td>Absent</td>
<td>4/6</td>
<td>Absent</td>
</tr>
<tr>
<td>9</td>
<td>28/F</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (29)</td>
<td>31</td>
<td>Progressive dyspnea and orthopnea 28 days, acute dyspnea 1 day. Left subscapular and left anterior chest pain</td>
<td>Muffled closing click. Absent opening click.</td>
<td>2/6</td>
<td>Absent</td>
</tr>
<tr>
<td>10</td>
<td>44/F</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (27)</td>
<td>43</td>
<td>14 days progressive dyspnea; 6 hours acute orthopnea and dyspnea; acute substernal chest pain</td>
<td>Muffled</td>
<td>1/6</td>
<td>Absent</td>
</tr>
<tr>
<td>11</td>
<td>42/F</td>
<td>Mixed mitral valve disease</td>
<td>MBS (27)</td>
<td>8</td>
<td>Acute dyspnea 1 day; pain and numbness right leg</td>
<td>Muffled</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>12</td>
<td>48/F</td>
<td>Tight rigid mitral stenosis</td>
<td>MBS (27)</td>
<td>3</td>
<td>Acute dyspnea 1 day; acute substernal chest pain</td>
<td>Muffled</td>
<td>2/6</td>
<td>Long</td>
</tr>
</tbody>
</table>

Abbreviations: TISM = tricuspid incompetent systolic murmur; MDM = mid-diastolic murmur; MBS = mitral Björk-Shiley; ABS = aortic Björk-Shiley.
12 had also had an aortic valve replacement (table 1). Anticoagulant therapy with warfarin sodium had been prescribed since the time of operation. There had been marked symptomatic improvement after surgery and the patients were, in fact, virtually asymptomatic before their present acute illness.

A clinical diagnosis of obstruction of the mitral prosthesis was made in all but patient 1. Echocardiography was performed in four patients. None underwent cardiac catheterization.

Clinical Features

The salient clinical features are listed in table 1. All but two patients became symptomatic only 1–3 days before admission and presented principally with extreme dyspnea and orthopnea. The exceptions (patients 9 and 10) had developed symptoms of left-heart decompensation over 4- and 2-week periods, respectively, and then became acutely dyspneic just before admission. Patient 12 noticed a decrease in the intensity of her prosthetic valve sounds four days before her acute episode. Pain and numbness of the right leg were noted by patient 11 a few hours before the onset of dyspnea, and an embolus to the right femoral artery was confirmed on admission. Nine patients had chest pain. Patients 1, 2, 4, 5, 6, 10 and 12 had substernal crushing pain and patients 1 and 4 also had right subscapular pain. Patients 3 and 9 presented with left subscapular pain. The subscapular pain in the four patients increased in intensity with respiration and coughing. Clinical examination revealed that all 12 patients were in congestive cardiac failure.

With one exception (patient 7), there were signs of poor peripheral perfusion: the extremities were cold, there was a small volume pulse and the systolic blood pressure was 90 mm Hg or less. No abnormality of the prosthetic valve sounds was detected in patient 1, but they were definitely muffled or absent in 10. The sounds were intermittently absent in patient 7. Eleven patients had a systolic murmur of tricuspid regurgitation. An increased intensity of the pulmonary component of the second sound and a right-sided gallop were present in all. Mitral murmurs were not a prominent feature. Three patients had a very short apical mid-diastolic murmur, which was intermittent in patient 7. Patients 3 and 12 had a long mid-diastolic murmur. We failed to detect a definite mitral regurgitant systolic murmur in any patient.

In all instances, inadequate anticoagulation was a notable factor. Three patients had stopped, for meaningless or irrelevant reasons, their anticoagulant therapy 2–7 days before admission. In the other nine, control of their prothrombin indices** was, or had been, unsatisfactory. The prothrombin index was above 70% in nine patients at the time of presentation.

In the remaining three (patients 8, 9 and 11), the prothrombin indices were 16%, 41% and 62%, respectively, on admission, but had consistently been above 65% in the preceding months. No clinical, laboratory or pathological evidence of infective endocarditis was detected.

Electrocardiograms

The 12 patients, seven of whom were in atrial fibrillation, had a tachycardia ranging from 90–120 beats/min. In patient 2, there was a shift of the mean frontal plane QRS axis from −15° to −60° with the acute episode. No other electrocardiographic changes were detected.

Chest Roentgenograms

Upper lobe blood diversion, cardiomegaly and bilateral interstitial edema (fig. 1) were features in all instances.

Echocardiograms

Echocardiograms recorded in patients 2, 5, 6 and 7 showed the reported features14 of a thrombosed Björk-Shiley prosthesis in the mitral position. The amplitude of valve excursion was markedly diminished as were the opening and closing rates. There was a rounding of
the upstroke and downstroke as well as a flattening during diastole. Very dense echoes posterior to the prosthesis were noted, even with gains reduced to the minimum (fig. 2).

Operative Findings

All but one of the 11 patients subjected to surgery had fresh thrombus that almost totally occluded the mitral prosthetic valve (figs. 3A and B). In these the Björk-Shiley valve was replaced with a Hancock porcine xenograft. The prosthetic valve of the remaining patient, a 48-year-old woman (patient 7) whose opening and closing clicks had been intermittently absent, had organized thrombus occluding the major orifice and this valve was replaced with another Björk-Shiley prosthesis. Patient 5 became hypotensive immediately after discontinuation of cardiopulmonary bypass, and it was readily apparent from pressure tracings that the Björk-Shiley aortic valve was obstructed. On reinstituting cardiopulmonary bypass, it was seen that the aortic prosthetic valve was occluded with fresh thrombus that had presumably been inadvertently dislodged from the thrombosed mitral prosthesis. This aortic prosthesis was replaced with another Björk-Shiley valve.

A prosthetic valve ring leak was recognized in the immediate postoperative period in patient 3, in whom reoperation was undertaken 4 months later because of progressive mitral regurgitation. Patient 5 developed wound and groin sepsis that responded to systemic antibiotic therapy and local wound care. Patient 12 remained symptomatic and in cardiac failure and required replacement of the stenotic porcine xenograft 1 year later with a 29-mm Björk-Shiley prosthesis. Nine patients had relatively uncomplicated postoperative courses. All 11 were well on the date of the last inquiry at the end of March 1978, and anticoagulation with warfarin was being maintained.

Necropsy Findings

The findings in the 50-year-old woman (patient 1) who died were similar to those of the patients sub-
jected to surgery. There was total thrombotic occlusion of the mitral prosthesis. No evidence of pulmonary embolism was detected.

Causes of Death in Other Patients

We obtained information on the 18 other deaths that occurred during the period of study among the 224 patients discharged from hospital. Six patients, three of whom were female, had an acute onset of cardiac failure and other clinical findings highly suggestive of prosthetic valve occlusion. Two of these had stopped oral anticoagulants, two had prothrombin indices of over 90% and there were no details of the anticoagulant therapy in the remaining two. Necropsies were performed in two of the six and confirmed the thrombosis of the mitral prostheses. A 19-year-old woman had had a 31-mm prosthesis inserted; 27-mm or 29-mm valves had been used in the other five patients. Dominant mitral regurgitation had been the indication for mitral valve replacement in three, a mixed lesion in two and mitral stenosis in the remaining patient. Two of the six, one of whom had necropsy confirmation of prosthetic thrombosis, had an associated systemic embolus.

Three of the other 12 deaths were due to embolic cerebrovascular accidents. Although the prosthetic valves in these three patients were assessed clinically as normal, necropsies were not obtained. The remaining nine patients died of causes not directly related to the Björk-Shiley prostheses. Four had had features of chronic myocardial failure, but the attending clinicians had specifically commented in the records that the prosthetic valve sounds were normal. Three of the four had necropsies and the prostheses were indeed normal. Two patients died of infection and one of a massive gastrointestinal hemorrhage associated with a low prothrombin index. Finally, a 46-year-old man died of bronchial carcinoma and a woman, age 54 years, committed suicide.

Discussion

Thromboembolic events are the most common and dreaded complication of cardiac prosthetic valves, including the Björk-Shiley prosthesis. Factors that reputedly predispose to thrombus formation are inadequate anticoagulant therapy, impaired left atrial emptying, a low cardiac output and turbulence related to valve design. Unsatisfactory anticoagulant control is apparently a major factor and this certainly applied in our patients. It has been shown that some subjects with tight mitral stenosis have a small left ventricle, which may interfere with prosthetic disc function and also possibly predisposes to delayed left atrial emptying. Seven of our 12 patients had had mitral stenosis as their only lesion, but the significance of this is uncertain. Of six other patients not examined by us but in whom we conclude that death was also due to prosthetic thrombosis, only one had had pure mitral stenosis. The size of the prosthetic valve was not relevant in our experience.

One (patient 7) of our 12 patients had a 25-mm valve inserted, whereas the 19-year-old woman with necropsy confirmation of prosthetic thrombosis had a 31-mm prosthesis. In the remaining 16 patients with proved or suspected thrombotic occlusion, either a 27-mm or a 29-mm prosthesis had been used. Once thrombus has formed on a prosthetic valve, systemic embolism or valve dysfunction may occur. Total thrombotic encapsulation of the prosthesis, similar to that found in our patients, has been encountered with the Björk-Shiley valve in the aortic, mitral and tricuspid positions.

The reported mortality associated with thrombotic encapsulation of the mitral Björk-Shiley prosthesis is extremely high and has been at least 80% in the experience of some. This is in contradistinction to the low mortality in our series and principally reflects delays in diagnosis and definitive surgical therapy.

Patient 1 died because thrombosis of the prosthetic valve was not detected on admission. Her chest pain was incorrectly attributed to pulmonary embolism. The clinical assessment, which was almost certainly incorrect, that the valve opening and closing clicks were normal contributed significantly to our error. In our subsequent experience, the prosthetic sounds, especially the opening click, were always absent or considerably muffled. Right-sided gallop sounds were uniformly present and a systolic murmur of tricuspid regurgitation was heard in 11 patients (table 1). Mitral murmurs, either systolic or diastolic, were unimpressive and a long, definitely abnormal, diastolic murmur was detected in only two instances (patients 3 and 12). Despite a low-output state in these patients, the velocity of blood flow across the encapsulated prosthesis must inevitably be considerably increased. A diffuse flow of blood through the thrombosed and distorted prosthesis is presumably the explanation for the frequent absence of an audible mitral diastolic murmur.

In addition to the abnormal auscultatory findings, significant presenting features included the relatively acute onset of dyspnea, the development of right ventricular failure and chest pain. In four of our patients, the cause of the chest pain, which was subscapular and aggravated by respiration, is uncertain. Myocardial ischemia is the likely explanation for the more common substernal crushing pain. Although chest pain was present in a patient reported by Spencer and co-workers, this symptom has apparently not been encountered by others.

It is apparent from the rapid progression of symptoms that once thrombosis of a Björk-Shiley prosthesis has commenced, critical obstruction to forward flow quickly ensues. Despite the immediate diagnosis of valve obstruction, the starting of appropriate medical therapy and the planning of surgery within 4–6 hours, the condition of patients 2 and 5 deteriorated so rapidly that femorofemoral bypass had to be instituted in order to maintain a circulation. We doubt indeed whether these two patients would have survived the delay necessitated by diagnostic cardiac catheterization, and the experience of others is
in accord with this view. Noninvasive procedures that are not time consuming, especially echocardiography \(^4\) and cineradiography, \(^3\) are useful adjuncts. The echocardiogram confirmed prosthetic valve malfunction in the four patients in whom this investigation was performed.

We conclude that the clinical features alone are sufficiently characteristic for obstruction of a mitral Björk-Shiley prosthesis to be diagnosed, or at least very strongly suspected. If echocardiography is available, this should invariably confirm the diagnosis. As soon as obstruction of the prosthesis is recognized, it is mandatory that the patient be referred immediately for surgery. The Björk-Shiley prosthesis should only be used in the mitral position if excellent control of anticoagulant therapy can be guaranteed. We are now inserting porcine xenograft valves into patients in whom it is anticipated that anticoagulant therapy will be less than ideal.

References

Thrombosed Björk-Shiley mitral prostheses.
H Copans, J B Lakier, R H Kinsley, P R Colsen, V U Fritz and J B Barlow

Circulation. 1980;61:169-174
doi: 10.1161/01.CIR.61.1.169
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1980 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on
the World Wide Web at:
http://circ.ahajournals.org/content/61/1/169.citation

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally
published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the
Editorial Office. Once the online version of the published article for which permission is being requested is
located, click Request Permissions in the middle column of the Web page under Services. Further
information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/