Echo-Phonocardiographic Evaluation of Obstruction of Prosthetic Mitral Valve*


Echo-phonocardiograms of 64 patients with multiple types of prosthetic mitral valves (PMV) were evaluated. Six patients demonstrated findings suggesting valve obstruction: four had surgical confirmation of prosthetic obstruction, one reduced cardiac output and pulmonary hypertension but no prosthetic dysfunction at surgery, and one is asymptomatic. Three of four patients with confirmed obstruction had variable second sound to opening click intervals (A2-MO) with interrupted disc opening; two had interrupted disc closure with split closing clicks and three of four had reduced diastolic closure rate. In 58 clinically well patients with PMV, cycle-to-cycle A2-MO varied little: 0-10 msec in sinus rhythm and 10-25 msec in atrial fibrillation. Diastolic closure rates of five different types of PMV were similar: 21.6 mm/sec, (range 14-49). No patient had interrupted opening, closing or multiple closing clicks. Thus, delayed PMV opening or closure, altered A2-MO interval and double closing clicks are highly useful in detecting patients with obstruction of a variety of mitral prostheses.

Multiple types of mitral valve prostheses have been utilized over the past 18 years, each with a peculiar set of advantages and problems.1-4 Dysfunction of these valves may result from ball or disc obstruction and entrapment by myocardial tissue or thrombus, thrombus formation with subsequent peripheral arterial embolization, valvular incompetence resulting from dehiscence with or without exaggerated hemolysis, and strut fracture.5-14 Non-invasive techniques such as echocardiography and phonocardiography have proven valuable in the long-term assessment of patients with prosthetic mitral valves and have been helpful in detecting abnormally functioning prostheses with paravalvular leaks, embolization and obstruction.15-25

Herein we report 64 patients in whom different types of mitral valve prostheses were evaluated by combined echo-phonocardiography comprising both ball and disc types. Fifty-eight patients were clinically stable and were used to develop standard measurements for comparison. Six patients had echophonocardiographic findings suggesting valve obstruction and each will be presented individually.

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Materials and Methods

Echo-phonocardiograms from 58 clinically stable patients with various types of prosthetic mitral valves were evaluated. The types of valves consisted of 33 discs (22 Beall and 11 De Bakey), 6 ball-cage of the Starr-Edwards type, and 19 tilting discs (13 Bjork and 6 Cooley-Cutter). Thirty-two patients were in chronic stable atrial fibrillation at the time of the study. Measurements of the interval from onset of the second heart sound to opening of the valve (A2-MO) were made in five cardiac cycles and averaged from echophonocardiograms obtained at paper speed of 100 mm/sec with the microphone placed along the lower left sternal border with frequency band width filters set at medium frequency range. The shortest and longest cycle-to-cycle variation in A2-MO through the five cycles analyzed was noted. The echocardiograms were inspected for the presence of interrupted opening or closing motion of the valve. In addition, the diastolic closure rate in mm/sec was measured as the E-F slope of the valve in five cardiac cycles and averaged. All studies were of diagnostic quality and performed utilizing standard echocardiographic techniques.

The echo-phonocardiographic studies from the six cases presented below were analyzed in a manner similar to the above.

Case Reports

Case 1

A 62-year-old man underwent mitral valve replacement with a large orifice Beall prosthesis in April, 1973 for severe mitral regurgitation of nonrheumatic origin. He was clinically well until February, 1975 when two syncopal episodes prompted readmission. Physical examination revealed the valve sounds to be crisp, but a variable time interval between the second heart sound and opening click was evident. Cardiac catheterization revealed a reduced cardiac index...
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(2.4 L/min/M²), elevated pulmonary capillary wedge pressure (mean = 22 mm Hg, V wave = 30 mm Hg); increased pulmonary artery pressure (40/22 mm Hg, mean = 30 mm Hg), and a mean diastolic gradient across the mitral prosthesis of 17 mm Hg. Left ventricular cineangiography demonstrated no mitral regurgitation and a normal ejection fraction.

Echocardiography performed prior to catheterization demonstrated marked enlargement of the left atrium (7.0 cm; normal, <4 cm), a dilated left ventricular cavity (7.0 cm; normal, <5.6 cm), well preserved ventricular septal motion, normal left ventricular shortening fraction (32 percent; normal, >30 percent) and circumferential fiber shortening rate (1.28 circ/sec; normal, >1.1). Echoes from the mitral prosthesis were obtained along the left sternal border according to previously described techniques.30 Mitral prostatic opening and closing velocities were within normal limits; disc excursion was .8 cm (normal, >.6 cm).31 An initial diastolic anterior motion of the prosthesis (labeled IO in Fig 1, panel A) occurred at a close and fairly constant interval (55 msec) following the aortic component of the second heart sound and was thought to represent initial opening of the prosthesis. A second abrupt anterior motion (labeled MO in Fig 1, panel A) occurred simultaneously with the opening click on the phonocardiogram at a variable interval from the initial (IO) motion. Presumably, this second motion represents maximal disc opening. The aortic closure sound to mitral prosthetic opening (A₂-MO) interval varied markedly from beat to beat (140 to 200 msec). The diastolic closure rate was 12 mm/sec.

Simultaneous echo-phonocardiographic and left ventricular and pulmonary capillary wedge pressure recordings (Fig 1, panel B) revealed that the early diastolic anterior motion of the prosthesis was initiated by the crossover of left ventricular and pulmonary capillary wedge pressures while final opening (the genesis of the opening click) did not occur until later in mid-diastole.

Because malfunction was suspected, the patient underwent replacement of his prosthesis. At the time of surgery, a left atrial thrombus was noted near the valve orifice and a small piece of papillary muscle was found lodged in the posterior edge of the strut of the prosthesis impeding disc motion during diastole. A medium-sized Beall mitral valve was inserted and the patient was clinically stable until the eighth postoperative day when cardiac arrest with unsuccessful resuscitation occurred. Autopsy revealed a large periprosthetic leak.

CASE 2

A 55-year-old man underwent mitral valve replacement in 1965 with a Smeloff-Cutter ball and cage prosthesis for rheumatic mitral stenosis. Postoperatively, he was well until three months prior to admission when atrial fibrillation associated with increasing fatigue was noted. Cardiac catheterization demonstrated severe pulmonary hypertension (pulmonary artery pressure = 110/40 mm Hg; mean = 70 mm Hg), normal left ventricular end-diastolic pressure (10 mm Hg), and an end-diastolic mitral valve gradient of 30 mm Hg. Left ventriculography revealed hypokinesis of the apex.

Echocardiography revealed a dilated left atrium and left ventricle with reduced left ventricular shortening fraction (15 percent). Examination of the prosthesis from the apex showed an initial diastolic anterior motion followed by final disc opening (MO) similar to Case 1 (Fig 2). The A₂-MO interval varied widely (120-240 msec). Intermittently, the valve failed to open in diastole despite appropriately long R-R intervals (fourth diastolic cycle, Fig 2). The diastolic closure rate was 8 mm/sec. As shown in Figure 2, closure of the prostheses was also observed to be interrupted. The initial closure motion (IC) was associated with a low amplitude sound on the phonocardiogram (C₁) while final closure...
(FC) was associated with the closure click (C₂). At times both final closure and closure click failed to occur (fourth cycle, Fig 2).

At operation, the findings were consistent with prosthetic obstruction. A panus of fibrous material covered the sewing ring and struts so that the ball was required to pass through a fibrous diaphragm causing the ball to intermittently become fixed in a semi-closed position. A No. 29 Hancock bioprosthesis was inserted, and the patient was subsequently discharged in a stable, clinically improved condition.

CASE 3

A 53-year-old woman with rheumatic mitral stenosis underwent mitral valve replacement with a No. 27 Cooley-Cutter prosthesis in 1971. In March, 1976, a large atrial septal defect was detected. The mean diastolic gradient across the prosthetic mitral valve was 8 mm Hg. Echo-phonocardiography revealed a right ventricular volume overload pattern, dilated left atrium, normal left ventricular dimensions and shortening fraction and normal mitral prosthetic motion. The A₂-MO interval was 80 msec, disc excursion was normal (0.8 cm) and the diastolic closure rate was 24 mm/sec. The atrial septal defect was closed and she was well until September, 1976 when two syncopal episodes occurred. Physical examination revealed a double mitral prosthetic closing click often preceded by a double opening click.

Echo-phonocardiography suggested a marked change from the previous examination (Fig 3). The A₂-MO interval was prolonged to 120 msec with some beats showing interrupted opening. The diastolic closure rate was 16 mm/sec. The most dramatic alteration related to the closure motion which was consistently interrupted and accompanied by two closing clicks on the phonocardiogram similar to patient 2.

The echo-phonocardiogram was considered diagnostic of severe prosthesis dysfunction, and because of rapid deterioration with multiple episodes of syncope and hypotension, the patient was immediately taken to surgery. Calcified fibrous material was found to occupy at least one-third of the area between the disc and seating ring thereby impeding proper closure. A small orifice Beall mitral prosthesis was inserted. Postoperatively, the patient did well and echocardiography performed one week later revealed normal prosthetic motion similar to that shown in Figure 5C.

CASE 4

A 49-year-old woman with rheumatic mitral stenosis underwent mitral valve replacement in 1972 with a No. 27 Bjork-Shiley prosthesis. The patient was well until April, 1977 when dyspnea and chest pain were noted. Right heart catheterization revealed pulmonary artery pressure of 75/25 (mean 50 mm Hg) and pulmonary angiography demonstrated marked delay of contrast passage from left atrium to left ventricle. A routine echocardiogram performed one month prior to admission before the onset of symptoms exhibited normal prosthetic disc motion with a diastolic closure rate of 22 mm/sec and an A₂-MO of 70 msec (Fig 4, panel A); no opening click or diastolic murmur was recordable by phonocardiography. A second echo-phonocardiogram performed at the time of admission (Fig 4, panel B) demonstrated a reduction in the diastolic closure rate (10 mm/sec) and shortening of the A₂-MO interval (40 msec). In addition, both opening and closing velocities of the disc were slower (52 and 104 mm/sec, respectively) than the previous study (240 and >400 mm/sec). During both echocardiographic evaluations, the patient was in sinus rhythm with a similar heart rate (115/min) and both studies were performed from the apex. Dysfunction of the prosthesis was
Figure 3. Echo-phonocardiogram of case 3, with a Cooley-Cutter mitral prosthesis. Notice the interrupted disc closure with the initial and final closing motions (IC and FC) corresponding to the first and second components ($C_1$ and $C_2$) of the closing click respectively. Likewise, disc opening is slightly interrupted and associated with a split opening click ($OC_1$ and $OC_2$). Abbreviations as in Figure 1.)

Figure 4. Echo-phonocardiograms of case 4 with Bjork-Shiley mitral prosthesis one month prior to admission (panel A) and at the time of admission (panel B). Both studies were obtained with the transducer at the cardiac apex. Note the shortening of the second heart sound ($A_2$) to mitral opening (MO) interval and the reduction in opening velocity (OV), closing velocity (CV) and diastolic closure rate (DCR) from the first to the second study despite similar heart rates. No opening clicks are recorded on the phonocardiogram.
suggested, the patient was taken to surgery and endothelial tissue was found to have extended over the prosthetic orifice, impeding disc motion. A Hancock porcine valve was inserted and the patient has been well since.

Case 5


At cardiac catheterization, cardiac index was 2.5 L/min/M², mean pulmonary capillary wedge pressure was 20 mm Hg with a V wave of 30 mm Hg and the pulmonary artery pressure was 40/20 mm Hg, mean 28 mm Hg. The left ventricular end-diastolic pressure was 12 mm Hg and the mean resting diastolic gradient across the mitral prosthesis was 10 mm Hg. Left ventricular angiography revealed no mitral regurgitation and normal ejection fraction. The patient was cardioverted and discharged in normal sinus rhythm without symptoms.

In May of 1977, the patient was readmitted with orthopnea, exertional fatigue, ascites and pedal edema. Auscultatory finding of a grade 2/6 holosystolic murmur along the left sternal border was unchanged; however, a diastolic rumble and varying second heart sound to mitral opening click intervals were noted.

Repeat cardiac catheterization revealed a diminished cardiac index of 1.9 L/min/M², similar pressures in the pulmonary artery and wedge position as in March 1976, hypokinesis of the left ventricular apex and severe tricuspid regurgitation. Pulmonary angiography was consistent with delayed emptying of the left atrium. The mitral disc motion was normal and there was no mitral regurgitation. Aortic root angiography demonstrated no aortic regurgitation.

An echocardiogram performed in 1975 after insertion of the prosthesis demonstrated dilated right and left ventricles with abnormal septal motion. Sharp and uninterrupted opening of the prosthesis was observed with normal disc excursion and diastolic closure rate of 12 mm/sec. A repeat study in March of 1976, at the time of the embolic episode, revealed an increase in the right ventricular dimension with a decrease in left ventricular size, improved left ventricular posterior wall motion and persistent abnormal septal motion. As shown in Figure 5, panel A, opening of the prosthesis appeared uninterrupted. The A₂-MO interval was prolonged, but did not vary significantly (160 ± 5 msec). The diastolic closure rate was 12 mm/sec and disc excursion was 0.5 cm. In May of 1977, during the second postoperative admission, echo-phonocardiography demonstrated an initial diastolic anterior motion of the prosthesis followed by a variable point of disc opening with A₂-MO varying widely (240 ± 60 msec). Additionally, an early diastolic murmur (prior to opening click) was recorded on phonocardiography suggesting that phasic flow across the prosthesis had begun prior to complete disc opening (Fig 5, panel B, see arrows marked DM).

Because of the severity of tricuspid insufficiency and the clinical suspicion of malfunctioning mitral prosthesis, the patient was taken to surgery. Inspection and digital examination of the mitral valve was performed by the surgeon, but no distinct abnormalities were observed. A disc prosthesis was placed in the tricuspid position. There was rapid resolution of symptoms postoperatively with a disappearance of both diastolic and systolic murmurs. Echocardiography performed two weeks following surgery demonstrated normal prosthesis motion for both implants (Fig 5, panel C). The diastolic closure rate was 20 mm/sec; the A₂-MO interval was 120 msec with minimal variation, and the initial diastolic anterior motion seen preoperatively was no longer present.

Case 6

A 13-year-old boy had undergone repair of an ostium secundum atrial septal defect associated with mitral regur-
proximity in 1967 at the age of five years. Over the subsequent 24 months, he suffered two separate episodes of congestive heart failure and in June, 1969, he underwent mitral valve replacement with a No. 103 medium disc Beall valve. In March 1973, he was readmitted, again in congestive heart failure. Atrial fibrillation was noted at this time. Cardiac catheterization revealed normal right and left-sided heart pressures, persistence of a left-to-right shunt at the atrial level with a pulmonic-to-systemic flow ratio of 1.8:1, left ventricular end-diastolic pressure of 8 mm Hg and a mean mitral valve gradient of 10 mm Hg. Left ventricular angiography demonstrated no mitral regurgitation and normal disc motion. The patient was cardioverted to normal sinus rhythm and discharged.

During a follow-up examination in February, 1975, the patient was again noted to be in atrial fibrillation, but without symptoms of congestive heart failure. Repeat cardiac catheterization in 1975 revealed hemodynamic findings similar to the study in 1973. Normal disc motion was noted fluoroscopically and no mitral regurgitation was detected angiographically. The left ventricular ejection fraction was reduced to 45 percent. An echocardiogram obtained on this admission demonstrated right ventricular, left atrial and left ventricular enlargement with paradox septal motion. Left ventricular posterior wall excursion was normal. Echoes from the mitral valve prosthesis (Fig 6) demonstrated initial diastolic anterior motion of the prosthesis followed by a later abrupt anterior motion of the disc similar to that seen in Case 1. Disc excursion was 0.6 cm. The opening click recorded on the phonocardiogram occurred simultaneously with final disc opening and the A2-MO interval was variable (160-260 msec). In contrast to Case 1, however, the diastolic closure rate of the mitral valve prosthesis was greater (30 mm/sec).

As of this report, the patient has done well without symptoms of dyspnea, syncope, or congestive heart failure.

RESULTS

Results of the measurements made in the 58 clinically stable patients with prosthetic mitral valves are summarized in Table 1. Except for patients with Starr-Edwards ball and cage prostheses, the A2-MO interval was similar in all types of mitral valve prostheses (average = 107.5 ± 27.1 [SD] msec). In the six patients with Starr-Edwards prostheses, A2-MO averaged 81.6 ± 10.3 msec. An opening click was easily recorded in all types of prostheses with the exception of the Bjork-Shiley valves. In all instances, the opening click (OC) coincided with the most anterior opening motion of the prosthesis (MO). In sinus rhythm, the variation in A2-MO (or A2-OC) from cycle to cycle ranged from 0 to 10 msec, while in atrial fibrillation, this interval ranged from 10 to 25 msec.

As shown in Table 1, the diastolic closure rate (DCR) was similar in all types of prostheses (average = 21.6 ± 6.5 mm/sec), the lowest and highest DCR observed being 14 and 40 mm/sec, respectively. Interrupted opening or closure of the prosthesis

Table 1—Data From 58 Clinically Normal Patients with Prosthetic Mitral Valves

<table>
<thead>
<tr>
<th></th>
<th>A2–MO (msec)</th>
<th>DCR (mm/sec)</th>
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<tbody>
<tr>
<td>Beall (n=22)</td>
<td>104.5 ± 21.8</td>
<td>21.8 ± 8.4</td>
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<tr>
<td>De Bakey (n=11)</td>
<td>116.4 ± 24.8</td>
<td>21 ± 3.7</td>
</tr>
<tr>
<td>Starr-Edwards (n=6)</td>
<td>81.6 ± 10.3*</td>
<td>20.5 ± 5.1</td>
</tr>
<tr>
<td>Bjork-Shiley (n=13)</td>
<td>97.7 ± 18.7</td>
<td>23.1 ± 5.0</td>
</tr>
<tr>
<td>Cooley-Cutter (n=6)</td>
<td>99.1 ± 34.7</td>
<td>20 ± 7.9</td>
</tr>
<tr>
<td>Total (n=58)</td>
<td>102.3 ± 23.7</td>
<td>21.6 ± 6.5</td>
</tr>
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Results shown are mean ± standard deviation with the range of values in parenthesis (*p < 0.001 when compared to all other valves)

A2–MO = second sound to valve opening interval; DCR = diastolic closure rate

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was not observed in the 58 studies. A double opening sound was not recorded phonocardiographically in the 52 patients with disc valves, but was observed in the six patients with Starr-Edwards prostheses. None of the 58 patients exhibited double closure sounds on phonocardiography.

DISCUSSION

Obstruction of a mitral valve prosthesis should be suspected in patients with prosthetic mitral valves who present with acute dyspnea, particularly when associated with syncope or dizziness. A “sticky-disc” syndrome has been described where intermittent failure of disc opening during diastole resulted in obstructed left atrial flow, with subsequent symptoms of pulmonary congestion and intermittent syncope. However, the severity of symptoms relates to the degree of disc or ball immobility. Sudden syncope or dizziness results when the valve intermittently fails to open while symptoms of pulmonary congestion occur when an obstructed valve requires high left atrial pressure to initiate disc opening. Cinefluoroscopy may be useful in noting abnormal seating of a prosthetic valve indicated by rocking of the disc. This abnormal motion, however, is usually only seen with gross prosthetic mitral valve dysfunction. Cardiac catheterization may be productive in demonstrating apparent prosthetic obstruction; however, it may fail to detect intermittent obstruction of the mitral prosthesis.

Echocardiography has proven to be a valuable diagnostic tool in the follow-up evaluation of patients with prosthetic mitral valves and investigations of various models have been reported. Interrupted opening and initial slurred diastolic anterior motion which is followed by a second abrupt anterior motion of the poppet has been described in various types of obstructed or impinged mitral prostheses of the Beall and Smeloff-Cutter variety (similar to Cases 1, 2, and 6). However, the presence of interrupted opening of the prostheses may not always indicate a severely malfunctioning prosthesis and has been reported in asymptomatic individuals. Case 6, in this report, would seem to support this observation. It is our opinion, however, that this type of motion is indicative of some type of early impingement which may not always result in clinical deterioration. It is possible that the atrial septal defect in Case 6 may have facilitated left atrial emptying, thereby preventing a greater increase in left atrial pressure. Interrupted opening was not observed in the 58 clinically stable patients studied. Thus, if we assume patient 6 to be a normal variant, the specificity of this sign would be 98 percent.

Interrupted closure alone may also be observed in instances of prosthetic valve impingement such as in patients 2 and 3; none of the 58 clinically stable patients demonstrated this abnormal motion (specificity = 100 percent). Case 2 represents the most dramatic example of abnormal prosthetic mitral valve motion. In addition to the presence of interrupted opening and closing of the prosthesis, intermittent complete failure of the valve to open was observed. A rounded and slurred mitral prosthesis opening and closing motion similar to that seen in Case 4 has been reported previously in malfunctioning Bjork-Shiley tilting-disc prosthesis. Thus, it is evident that considerable variability of prosthetic mitral valve motion abnormalities may occur and qualitative echocardiographic assessment may or may not always be diagnostic of obstruction.

The addition of phonocardiography appears to enhance the echocardiographic assessment of mitral prostheses. Normally, a mitral valve prosthesis opens in an uninterrupted manner so that A2-MO provides an index of isovolumic relaxation time and therefore may be shortened by excessive increases in left atrial pressures. In the 58 patients with clinically stable mitral prostheses, A2-MO averaged 102.3 msec and appeared similar in all types of prostheses except in the Starr-Edwards ball and cage type where it tended to be shorter (81.6 + 10.3 msec, P < .001). This may be reflecting a greater degree of left ventricular inflow obstruction resulting from impingement of the left ventricular cavity by the larger cage. The shortest A2-MO interval recorded in any type of normally functioning prosthesis was 60 msec.

Brodie et al have shown a correlation between shortening of A2-MO and high left atrial pressures secondary to obstructed prostheses. Case 4 exemplifies this observation in that progressive shortening of A2-MO to 40 msec correlated with development of symptoms of mitral valve obstruction.

In the presence of interrupted or delayed mitral opening, the A2-MO may become markedly prolonged and vary significantly (>25 msec) from cycle to cycle as described in patients 1, 2, 5, and 6 and noted by others. As previously discussed, this probably represents impingement of the disc or ball. In these cases, the A2 to initial diastolic anterior motion (IO) interval, when present, remains relatively constant and probably reflects isovolumic relaxation. Thus, the variation of A2-MO (or A2-opening click) interval in these studies results primarily from variation in the IO-MO interval, probably resulting from varying degrees of impingement from cycle to cycle. This is exemplified in Case 1, Figure 1B, where the initial opening motion begins shortly after the crossover of the left ventricular and pul-

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monary capillary wedge pressures while final disc opening occurs (MO) at a variable time thereafter.

Other investigators have described a diminished intensity of the closure sound in malfunctioning mitral prostheses. However, we know of no echo-phonocardiographic report describing double closure clicks in patients with prosthetic valve dysfunction. This finding was not observed in any of the 58 clinically stable patients. In both cases 2 and 3, interrupted closure of the prosthesis demonstrated by echocardiography was associated with two simultaneous closure sounds recorded by phonocardiography. Each patient had surgical confirmation of an obstructed mitral prosthesis. Thus, it seems that C1 was produced by the initial closure motion and C2 by the final closure.

The diastolic closure rate of the prosthesis, a possible index of left ventricular diastolic filling rate, may also be of value in identifying obstructed prostheses. The results from our evaluation of 58 clinically stable patients with mitral valve prostheses indicate that the diastolic closure rate is similar in different types of prostheses having a mean value of 21.6 mm/sec and a range of 14-49 mm/sec. Three of the four patients in this investigation with surgically confirmed obstructed prostheses (cases 1, 2, and 4) had reduced diastolic closure rates (<14 mm/sec). In addition, case 5 also had a diminished diastolic closure rate. Therefore, a diastolic closure rate of less than 14 mm/sec is suggestive of markedly impaired left ventricular filling and should arouse suspicion of an obstructed prosthetic valve, especially in those patients presenting with recent onset of congestive symptoms. Nonetheless, it should be realized that marked alterations in dynamics of left ventricular filling secondary to abnormal left ventricular compliance could potentially lead to abnormal reduction in the diastolic closure rate.

Patient 5 demonstrated multiple findings suggesting prosthetic dysfunction: interrupted opening with variable prolongation of the A2-MO interval, a new diastolic murmur preceding the opening click, reduced diastolic closure rate, elevated pulmonary capillary wedge pressure with normal left ventricular diastolic pressures and reduced cardiac output. These findings could have been the result of endocardial tissue impinging upon the prosthesis with subsequent resolution after digital examination and realignment of the prosthesis. However, it appears more likely that they resulted from severe reduction in flow through the prosthesis (cardiac index = 1.9 L/min/M²) secondary to severe tricuspid valve incompetence since the surgeon was unable to demonstrate impingement of the disc and all the abnormalities resolved after tricuspid valve replacement.

If this was the case, extreme reduction in mitral valve flow may create a diagnostic dilemma in the recognition of prosthetic valve dysfunction.

In conclusion, M-mode echocardiography combined with phonocardiography is a valuable tool in detecting the presence of prosthetic mitral valve impingement. Although echocardiographic and phonocardiographic evidence of abnormal A2-MO intervals, reduced opening and closing velocities, or decreased disc excursion may often be observed in prosthetic valve dysfunction, reduced mitral flow, increased left ventricular diastolic pressure or abnormal left ventricular systolic performance might at times alter these indices. However, in concert with the sudden onset of dyspnea with syncope, the constellation of echo-phonocardiographic findings described in this investigation may be considered to be highly suggestive of prosthetic mitral valve obstruction.

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