Malfunction of a Smeloff-Cutter mitral valve prosthesis diagnosed by simultaneous echocardiographic imaging of the prosthesis and the tricuspid valve[1]

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The case of a young woman with a malfunction of a Smeloff-Cutter mitral ball-valve prosthesis 17 years after insertion is reported. Simultaneous M-mode echocardiographic imaging of the mitral valve prosthesis and the tricuspid valve was used to demonstrate the imperfect operation of the mitral ball-valve prosthesis. This imaging technique can objectively demonstrate the timing of opening and closing of the mitral valve poppet, compared to the native tricuspid valve motion, even in the presence of an irregular rhythm.

Index terms: Heart, ultrasound studies • Heart valve prosthesis, adverse effects • Mitral valve

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In patients with artificial heart valves, thrombosis of a caged-ball prosthesis is a serious and potentially fatal complication. We describe the use of simultaneous M-mode echocardiographic recording of the tricuspid valve and a mitral caged-ball prosthesis to assist in the diagnosis of prosthetic valve malfunction.

Case report

A 33-year-old woman was admitted to the hospital with complaints of tachycardia and shortness of breath of one month's duration. When she was 16 years old, her mitral valve was replaced with a Smeloff-Cutter caged-ball valve prosthesis for the management of mitral stenosis and regurgitation. In the postoperative period and thereafter, sustained atrial fibrillation persisted. She was treated with warfarin sodium, however, the dosage was not enough to be beneficial and she sustained several cerebral embolic episodes, without permanent neurologic sequelae, during the first postoperative year. The warfarin sodium dosage was then increased, and she did well without further emboli developing. Upon admission, her blood pressure was 110/70 mm Hg, and her pulse was 130 beats/min and irregular. Her respiration rate was 25/min. Her temperature was 37.2° C. The neck veins were distended to 4 cm above the clavicle while she was sitting erect. A left parasternal precordial lift was palpable. The prosthetic valve sounds were markedly attenuated and varied in intensity. When this was mentioned to the patient, she stated that she stopped hearing the valve click at about the same time she began to feel ill. An intermittent grade III/VI apical systolic murmur radiated to the axilla. The chest radiograph showed gross cardiomegaly, pulmonary congestion, and bilateral small pleural effusions. The electrocardiogram revealed atrial fibrillation with a rapid ventricular response and right-axis deviation.

Two-dimensional and M-mode echocardiography was performed. A giant left atrium, dilated right ventricle, and a small, normally contracting left ventricle were demonstrated. The ball valve seemed to stick in the cage when viewed by two-dimensional echocardiography, but the irregular rhythm made this observation uncertain. The tricuspid valve and the mitral caged-ball prosthesis were imaged simultaneously, and an M-mode tracing was recorded (*Fig. 1*). According to this tracing, the tricuspid valve briskly opened with each QRS complex, but the timing of the opening of the ball valve varied from beat to beat and failed to open on two beats during which time the tricuspid valve opened. In addition, once open, the ball valve had a decreased rate of closure, that is, the closure slope was less steep.

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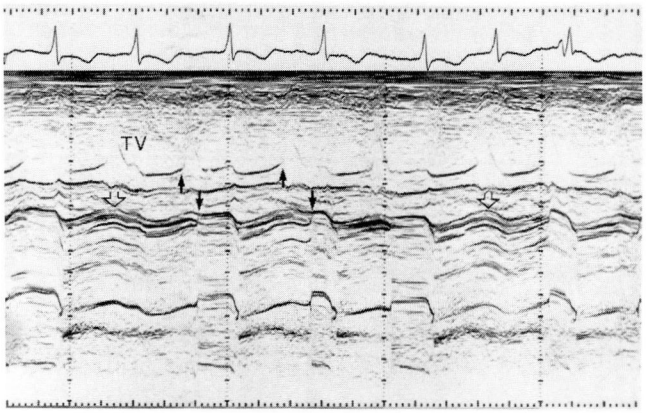

Fig. 1. Movements of the tricuspid valve (*TV*) and the Smeloff-Cutter mitral valve prosthesis were recorded simultaneously by M-mode echocardiography. The *small arrows* pointing up indicate normal tricuspid valve opening; the *small arrows* pointing down indicate variably delayed opening of the mitral valve prosthesis. The poppet closure rate is also decreased. The *large open arrows* point to the instances when the poppet failed to open during normal tricuspid valve motion. Small time lines = 40 m/sec.

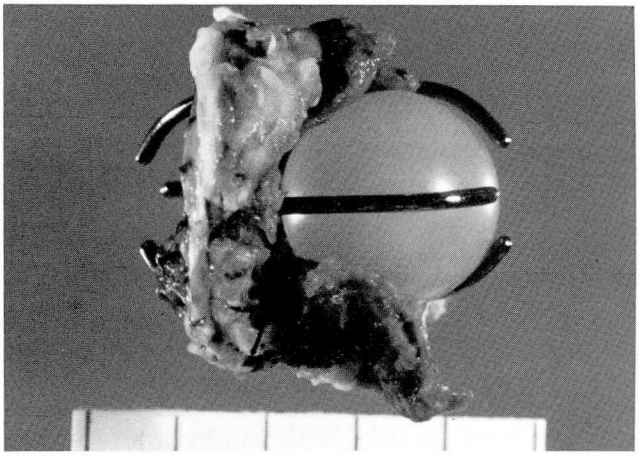

Fig. 2. Explanted Smeloff-Cutter mitral valve prosthesis, showing a normal poppet and ventricular and atrial struts. Tissue is ingrown from the suture ring toward the cage.

The patient was taken to surgery. The struts and sewing ring of the prosthetic valve were invested with a dense fibrous tissue that formed an encircling girdle and restricted the opening and closing motion of the normal poppet. The mechanical valve was replaced with a porcine bioprosthesis. The pathologic specimen is shown (*Fig. 2*).

Discussion

Thrombosis of ball valves and tilting disk valves in the mitral position has been described.[1–6] The clinical picture is usually characterized by the rapid onset of heart failure mimicking mitral stenosis and/or regurgitation in a patient who has had inadequate anticoagulation, a history of previous arterial emboli, and a recent loss of prosthetic click sounds. The patient usually has marked orthopnea and cannot tolerate heart catheterization which could confirm the diagnosis of prosthetic mitral valve malfunction. The noninvasive techniques of phonocardiography and echocardiography have been used to obtain objective data to support the clinical suspicion of prosthetic valve malfunction in this type of patient. The right atrium and right ventricle are often dilated secondary to pulmonary hypertension caused by the intermittent obstruction of the mitral valve orifice. This makes the tricuspid valve more visible echocardiographically. By using two-dimensional echocardiography with two M-mode cursor capability, the mitral valve prosthesis and the tricuspid valve can be imaged simultaneously by the two-dimensional long-axis view, and the M-mode cursor can record the motion of both valves separated by the ventricular septum. *Figure 1* shows that the mitral poppet opened from 40 to 120 msec after the tricuspid leaflets or the poppet did not open at all. Similarly, the apical four-chamber view can be used with two M-mode cursors to simultaneously image the tricuspid valve and the mitral ball-valve prosthesis. *Figures 3* and *4* were obtained by using this technique to evaluate patients with normally functioning Smeloff-Cutter mitral valve prostheses. In patients with a regular rhythm (*Fig. 3*), the mitral poppet opens with each beat approxi-

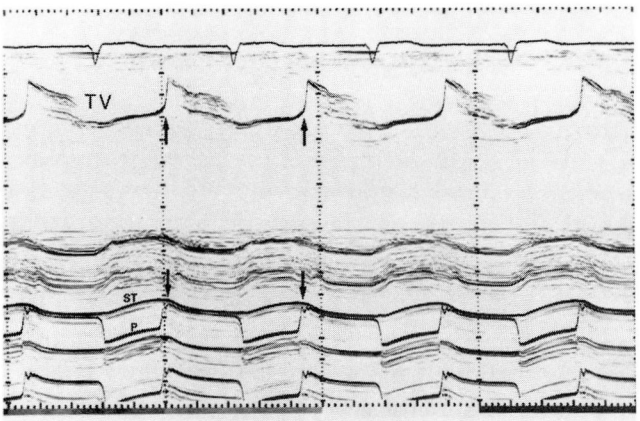

Fig. 3. Movements of the tricuspid valve (*TV*) and a normal Smeloff-Cutter mitral valve prosthesis were recorded simultaneously by M-mode echocardiography. Rhythm was regular. The *arrows* pointing up indicate normal tricuspid valve opening, occurring slightly after normal mitral prosthesis opening as indicated by the *arrows* pointing down. The poppet closure rate is brisk and constant. *P* = poppet and *ST* = struts. Small time lines = 40 m/sec.

mately 40 msec before the tricuspid leaflet; the timing and rate of closure are nearly constant. In a patient with atrial fibrillation (*Fig. 4*), the mitral poppet again opens slightly before the native tricuspid valve, and with a long diastole, the poppet drifts towards closure similar to the native tricuspid valve. Berndt et al[6] used phonoechocardiography to detect mitral prosthesis malfunction. According to their data, if the interval between the second heart sound and the prosthetic opening click is greater than 20 msec in sinus rhythm and greater than 30 msec in atrial fibrillation, prosthesis malfunction is indicated. Since these intervals are rate-dependent, empiric measurements can be inaccurate. They also demonstrated diastolic ball drift towards the closed position during long R-R intervals occurring with atrial fibrillation and offered five possible mechanisms to explain this phenomenon without coming to a firm conclusion.

In the case presented here, *Figure 1* showed failure of the valve to open after a QRS complex on two occasions. This finding alone is diagnostic of prosthesis malfunction. Yet, all cases of valve malfunction are not this clear. When poppet opening or closure is only delayed, dual-valve echocardiography can be extremely helpful. In addition, when using this imaging technique, it is not necessary to integrate the phonocardiogram with the echocardiogram to diagnose mitral valve prosthetic malfunction. The technical problems of timing rate-dependent phonocardiographic events in acutely ill patients with atrial fibrillation are avoided. In cases of variable poppet closure (*Figs. 1* and *4*), only motion different from the native valve is considered abnormal.

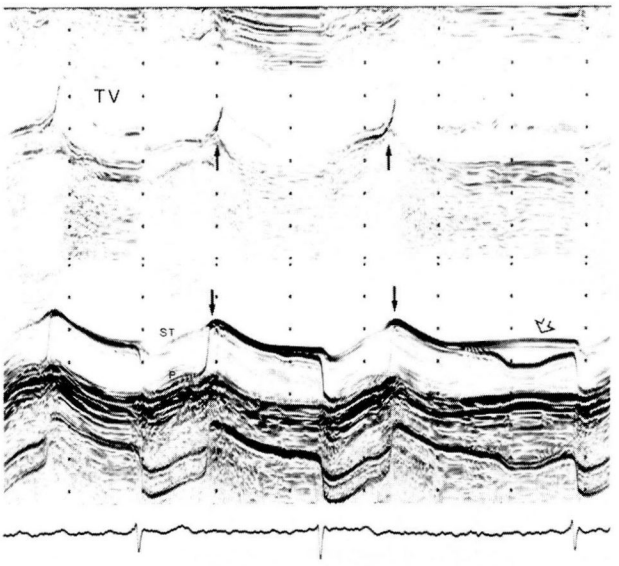

Fig. 4. Movements of the normal Smeloff-Cutter mitral valve prosthesis and the tricuspid valve were recorded simultaneously by M-mode echocardiography in a patient with atrial fibrillation. *Black arrows* indicate the opening of the prosthetic valve shortly before the native tricuspid valve (*TV*) opening. The *open arrow* indicates a semiclosure of the poppet during a long diastole, paralleling native tricuspid valve motion. *P* = poppet and *ST* = struts.

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