years. The patient had cyanosis on this admission in conjunction with recurrent CCF. TTE then revealed shunt reversal, explaining the onset of cyanosis.

One possible cause of shunt reversal was that the severe TR was directing the flow into the ASP, causing shunting to the left atrium as the severity increased. Another possibility was the change in the pressure gradient between the left and right atria: the pressure in the right atrium was 5 mm Hg higher than the pulmonary capillary wedge pressure at the time of the right heart study. This might be due to the combination of worsening pulmonary hypertension and TR.

A reversal of shunt needs to be considered when there is a sudden onset of cyanosis during the follow-up after PTMC for MS. In such

cases surgical correction should be considered in the treatment options, especially in the setting of significant valve disease.

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Successful lysis of an aortic prosthetic valve thrombosis with a dosing regimen for peripheral artery and bypass graft occlusions

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Video clips are available online.

Although valve thrombosis is infrequent, patients with prosthetic valves have a lifelong risk of this complication. Because operative mortality can be significant, thrombolysis has emerged as an alternative therapy for high-risk surgical patients.¹⁻³ Recent reports have included the use of tissue-type plasminogen activator because of the unavailability of other agents^{4,5}; however, the application of thrombolysis may be limited by increased risks of thrombus dislodgment, distal embolization,¹ and hemorrhagic complications.³

Rapid infusion of thrombolytic agents has also been associated with higher complication rates.^{4,5} By determining the lowest effective infusion dosage, the infusion rate and duration can be set to minimize risks of thromboembolism and hemorrhage. To our knowledge, there are no data on the lowest effective dosing regimen

for specific patient subsets. It is likely that patients who are hemodynamically unstable require rapid lysis, and current recommended protocols³ are indicated. For patients who are hemodynamically stable, however, a slower rate of infusion may be warranted. We present a case of prosthetic valve thrombosis successfully treated with a low-dose regimen of recombinant tissue-type plasminogen activator (rtPA, 1 mg/h without bolus), such as is typically used for peripheral artery bypass graft occlusions. Such an approach for treatment of prosthetic valve thrombosis has not been reported previously.

Clinical Summary

A 55-year-old woman with a mechanical aortic valve prosthesis (St Jude 19 mm; St Jude Medical Inc, Minneapolis, Minn) was seen for two days of exertional chest pain associated with nausea and diaphoresis. Two weeks before her admission, without seeking medical advice, the patient discontinued her warfarin sodium therapy. Physical examination revealed normal vital signs. Results of cardiopulmonary examination were unremarkable except for muffled aortic prosthetic valve sounds. Electrocardiography revealed normal sinus rhythm and left ventricular hypertrophy with strain.

Transthoracic echocardiography suggested restricted motion of aortic prosthetic leaflets, with turbulent flow on color flow Doppler scan. Continuous-wave Doppler echocardiography confirmed severe obstruction, with peak and mean gradients of 158 mm Hg and 86 mm Hg, respectively (Figure 1, A). There was mild aortic insufficiency. No obvious thrombus was seen. The left ventricle was normal in size, with normal systolic function and normal wall thickness. Fluoroscopy revealed decreased excursion of both aortic prosthetic leaflets (Figure 2, A; Video 1). The patient was admitted to the coronary care unit. Because of the patient's relative hemodynamic stability and the risk of reoperation, a trial of thrombolysis was elected. Both streptokinase and urokinase were unavailable at our institution and other nearby hospitals. We therefore chose a regimen of rtPA to achieve gradual lysis at the lowest effective dose and thus minimize

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Figure 1. Continuous Doppler echocardiography before and after thrombolysis. **A**, Continuous Doppler echocardiography of aortic mechanical valve before thrombolysis shows peak transvalvular systolic gradient of 156 mm Hg and mean gradient of 86 mm Hg. There is evidence of mild reverse diastolic flow (aortic insufficiency, *large single arrow*). **B**, Five days after thrombolysis, peak and mean gradients have normalized to 48 and 25 mm Hg, respectively. There is no aortic insufficiency, and a normal mitral inflow pattern is seen (*asterisk*). There is normal prosthetic opening and closure artifact (*small double arrows*). **C**, Graph of mean and peak aortic valve gradients shows gradual decreases with time. Gradients returned to values comparable to baseline measurements obtained 1 year previously.

thromboembolic and hemorrhagic complications. A regimen designed for lysis of peripheral artery bypass graft occlusions was initiated. Specifically, a continuous intravenous infusion of rTPA (1 mg/mL) was begun at a rate of 1 mg/h. A bolus was not given. A fixed-dose heparin infusion of 300 units/h ($3 \text{ u/[kg} \cdot \text{h]}$) was initiated.

Another echocardiogram 24 hours after infusion also revealed decreases in the peak and mean pressure gradients across the aortic valve, to 114 and 71 mm Hg, respectively. At 24 hours after initiation of therapy, both D-dimer and activated partial thromboplastin time were increased and fibrinogen was decreased. Daily echocardiograms revealed gradual reductions in the mean and peak gradients. After 80 hours of infusion and a total of 80 mg rTPA,

2-dimensional echocardiography and color flow Doppler scan showed improved mobility of the valve leaflets, with peak and mean gradients of 48 mm Hg and 25 mm Hg (Figure 1, B), respectively, similar to the gradients obtained 1 year previously. Fluoroscopy confirmed normal motion of the prosthetic valve (Figure 2, B; Video 2). The patient's symptoms resolved. Heparin and warfarin sodium were then initiated. The patient left against medical advice and was transitioned from enoxaparin to warfarin sodium.

After her initial presentation for prosthetic valve thrombosis, the patient was admitted for psychiatric evaluations on two separate occasions, which occurred 4 and 11 months later. Echocardiography at that time revealed normal prosthetic valve function. The mean

Figure 2. Cinefluoroscopy before and after thrombolysis. **A**, Cinefluoroscopy before thrombolysis shows restricted motion of both prosthetic valve leaflets. At end diastole, the valve cannot fully close. **B**, After thrombolysis, motion of prosthetic valve leaflets has returned to normal. At end diastole, the valve is fully closed, and prosthetic leaflets are perpendicular to the valve orifice.

gradients on echocardiograms performed during these admissions were 23 and 26 mm Hg, respectively (Figure 1, C). Unfortunately, the patient died shortly thereafter from complications related to diabetes.

Discussion

Although this experience is limited to a single case, a low-dose rt-PA regimen with longer infusion duration is a promising approach for patients who are in hemodynamically stable condition and do not require rapid lysis. There may be a lower complication rate because of the significantly lower infusion rate, despite longer infusion duration. Patients should be monitored closely for adequate lysis. This includes daily echocardiography and laboratory evaluations (D-dimer, activated partial thromboplastin time, and fibrinogen). Fluoroscopy should be used to confirm leaflet motion. Further investigation is necessary to evaluate the short- and long-term efficacy and safety of this treatment strategy.

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Arterial coronary revascularization failure as a result of coronary vasospasm

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Total arterial revascularization (TAR) is an option for the surgical treatment of ischemic heart disease.¹ It provides better long-term patency than do venous aortocoronary bypasses. TAR seems to offer the most benefit to the patient when combined with the off-pump "aorta no-touch" technique.²

Kobayashi and colleagues³ described a TAR technique that comprises two in situ internal thoracic arteries (ITAs) and a radial artery (RA) used as an I composite graft. They reported that to avoid the competition phenomenon in the graft, the distal end of the I composite should be placed on the right coronary artery (RCA) when this exhibits at least 80% stenosis.

Dr Gwozdziwicz

Clinical Summary

A 76-year-old man was admitted to our department for elective coronary surgery. Preoperative angiography revealed triple-vessel disease with 40% left main coronary artery stenosis, 90% left anterior descending coronary artery stenosis, 90% diagonal artery stenosis, 80% circumflex artery stenosis, and at least 80% proximal RCA stenosis (Figure 1). Echocardiography showed good left ventricular function with no valve disease. The patient had extensive varicose veins on both lower extremities and negative results of an Allen test on both hands. A Doppler examination revealed RAs of good quality with adequate collateral flow.

Quadruple off-pump coronary bypass grafting was performed with the left anterior descending coronary artery bypassed individually by the left ITA. The diagonal artery, obtuse marginal artery,

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