with this integrated approach,¹⁰ detailed evaluation in larger randomized multicenter studies is warranted to document long-term effectiveness of hybrid revascularization compared with conventional coronary artery bypass grafting or interventional therapy alone.

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REFERENCES

1. Cameron A, Davis KB, Green G, et al. Coronary bypass surgery with internal-thoracic-artery grafts: effects on survival over a 15-year period. *N Engl J Med* 1996;334:216-9.
2. Calafiore AM, DiGiammarco G, Teodori G. Left anterior descending coronary artery grafting via left anterior small thoracotomy without cardiopulmonary bypass. *Ann Thorac Surg* 1996;61:1658-65.
3. Subramanian V, Stelzer P. Clinical experience with minimally invasive coronary artery bypass grafting (CABG). *Eur J Cardiothorac Surg* 1996;10:1058-63.
4. Friedrich GJ, Bonatti J, Dapunt OE. Preliminary experience with minimally invasive coronary-artery bypass surgery combined with coronary angioplasty. *N Engl J Med* 1997;336:1454-5.
5. Angelini GD, Wilde P, Salerno TA, et al. Integrated left small thoracotomy and angioplasty for multivessel coronary artery revascularization. *Lancet* 1996;347:757-8.
6. Zenati M, Cohen HA, Griffith BP. Alternative approach to multivessel coronary disease with integrated coronary revascularization. *J Thorac Cardiovasc Surg* 1999;117:439-46.
7. Wittwer T, Cremer C, Boonstra P, et al. Myocardial "hybrid" revascularisation with minimally invasive direct coronary artery bypass grafting (MIDCAB) combined with coronary angioplasty: preliminary results of a multicenter study. *Heart*. In press.
8. Jansen EWL, Borst C, Lahpor JR, et al. Coronary artery bypass grafting without cardiopulmonary bypass using the Octopus method: results in the first one hundred patients. *J Thorac Cardiovasc Surg* 1998;116:60-7.
9. Spooner TH, Dyrd PE, Monson BK, Dixon GE, Robinson LD. Coronary artery bypass on the beating heart with the Octopus: a North American experience. *Ann Thorac Surg* 1998;66:1032-5.
10. Cohen HA, Zenati M, Smith C, et al. Feasibility of combined percutaneous transluminal angioplasty and minimally invasive direct coronary artery bypass in patients with multivessel coronary artery disease. *Circulation* 1998;98:1048-50.

12/8/100612

Mechanical mitral valves without long-term anticoagulation up to thirteen years

To the Editor:

If a mechanical valve could be left without anticoagulation, a continuous risk factor for severe bleeding, with an incidence of around 1% every year, could be avoided.

Fig 1. The microporous surfaced 25 mm mitral Björk-Shiley Monostrut heart valve after 2½ years without anticoagulation in a goat. The valve is viewed from the left ventricle with the disc in the open position. The carbon-coated Teflon suture ring is covered with thin, smooth, glistening yellow endothelium extending over the groove and adjacent part of the valve flange.

Ordinary Björk-Shiley Monostrut heart valves (Shiley, Inc, Irvine, Calif) were inserted in the mitral position in goats. After 1 year without anticoagulation, we found no instances of thrombosis on the pyrolytic discs or on the metal struts, but the suture rings in all cases were covered by an endothelialized layer of thrombus. From this layer a thrombus did protrude into the valve orifice in 8 of 9 goats.

The solution was to catch the covering from the suture ring and have it endothelialized and firmly fixed to the metal ring.¹ It was possible to sinter small, 20 to 30 µm round pearls of the same metal to the metal ring of the valves at high temperature in 3 layers. This enables roots to develop between the pearls so that the covering will not come loose. An endothelialized covering always developed on microporous surfaced rings tied into the superior vena cava in goats.² With 100 µm pearls the vascular covering was too thick.²

In 1984 we started to implant the microporous surfaced mitral valve in goats. After 2½ months without anticoagulation, the microporous area showed a homogeneous endothelialized surface with nutrition direct from the blood so that it stayed thin for more than 5 years.³ The continuous covering from the suture ring went over the groove down in the valve, and after 5 years without anticoagulation the valve was still nicely covered and the goats produced offspring without problems.³

The pilot study. This microporous surfaced mitral valve prosthesis has the same strength as the Björk-Shiley Monostrut valve,⁴ which has been implanted in about 140,000 patients during a 17-year period without any mechanical failures. We operated on a small group of 12 patients 11 and 13 years ago.⁵ All these patients had sinus rhythm. There were 5 children aged 7 to 15 years with mitral insufficiency and cardiomegaly.⁵ Patient 10 was cachectic and needed enteral nutrition for weeks before the operation. An 8-year-old boy (case 9) had a severe form of sickle cell anemia, with a hemoglobin

Table I. Laboratory results in the fall of 1998

Case	Date of operation	Valve size (mm)	Age in 1998	Pregnancy	Hematocrit (%)	LDH (U/L)	AST (U/L)	ALT (U/L)
1	5/13/1985	27	52					
2	5/14/1985	29	50		32	257	18	4
3	5/16/1985	27	43		34	194	14	8
4	3/19/1987	29	29	1	37	235	13	5
5	3/18/1987	25	21		44	323	36	10
6	3/23/1987	25	18		38	130	9	6
7	3/24/1987	31	26	4	38	264	18	5
8	3/26/1987	27	53		43	281	16	11
9	3/27/1987	27						
10	4/14/1987	31	26	2	22	477	16	6
11	5/4/1987	31	33		39	421	32	10
12	6/19/1987	27		2				

LDH, Lactic dehydrogenase; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

Table II. Doppler echocardiographic assessment

Case	LVD (mm) (1)	LVD (mm) (2)	LVEF (%) (1)	LVEF (%) (2)	LA (mm) (1)	LA (mm) (2)	MVA (cm ²) (1)	MVA (cm ²) (2)	PAsP (mm Hg) (1)	PAsP (mm Hg) (2)	TEE PVL (1)	TEE TVL (1)
2	53	53	40	50	47	46	2.4	2.4	34	30	0	0
3	35	48	65	70	35	42			25	33	0	0
4	53		50		37		2.0		30	—	0	2+
5	51	48	55	67	42	46	2.7	2.6	23	34	0	2+
6	46	48	55	72	55	54	1.3	1.1	44	47	0	0
7	56	59	53	55	64	64	2.2	2.2	31	31	2+	2+
8	41	50	65	60	48	51	3.1	3.0	—	—	0	1+
10	61	62	35	66	48	50	2.2	2.0	43	33		
11	52	56	55	64	49	53	2.4	2.4	27	—	0	2+

Investigations were performed in the summer of 1995 (1) and the fall of 1998 (2). LVD, Left ventricle at the end of diastole; LVEF, left ventricular ejection fraction; LA, left atrium; MVA, mitral valve area. PAsP, pulmonary artery systolic pressure; TEE, transesophageal echocardiography; PVL, paravalvular leakage; TVL, transvalvular leakage.

S value of 95%, and required exchange transfusion before the operation. He died 3.8 years after the operation of a sickle cell crisis with joint hemorrhage. The valve was normal at autopsy. The second death (patient 12) occurred 4.4 years after the operation from the rupture of a mycotic cerebral aneurysm. The valve sounds were normal.

The entire surface was microporous in the 3 first patients (1, 2, and 3). In all others (patients 4-12) the contact area between the disc and the struts was polished. As soon as the chest tubes were removed, heparin was given together with warfarin until an effective level was reached. The heparin was then discontinued and the warfarin continued for 3 months, that is, until the endothelialization of the microporous surface was complete. The patient then remained in the hospital for 7 days during subcutaneous heparin treatment after warfarin was withdrawn. No anticoagulant has been given since for 11 to 13 years.

Cardiologists have performed the follow-up every third month for those living close to the hospital and once a year for the others. A Doppler echocardiogram (including trans-

esophageal echocardiography) was performed in July 1995. The last clinical and echocardiographic follow-up examination was in the fall of 1998.

Results. Not a single thromboembolic complication has been observed. Transesophageal echocardiographic Doppler investigation performed during the summer of 1995 did not show any thrombi. During the follow-up period, 9 pregnancies occurred. All surviving patients were followed up during the fall of 1998. Only patient 1 did not come to the clinic but was contacted by telephone. No thromboembolic episode had occurred. Patients 6 and 10 were in New York Heart Association class II and the remaining 8 patients were in class I. Patients 6 and 10 had moderate tricuspid regurgitation and patient 10 also moderate aortic regurgitation. No one else had any other significant native valvular dysfunction. All 10 survivors were in sinus rhythm and had normal kidney function. The follow-up results are summarized in Tables I and II.

Discussion. For mitral valves the whole metal surface area can be microporous, as it was in the first 3 patients. It is, how-

ever, better to have all metal areas where the disc hits the struts polished, as in all other patients (patients 4-12).

The area adjacent to the suture ring is the important place to have a microporous surface to bind down the covering from the suture ring. After 11 to 13 years of follow-up of 12 patients with the Björk-Shiley Monostrut mechanical mitral valve with a microporous surface and without anticoagulation, 9 children have been born and no thromboembolic complications have been encountered.

Summary. This microporous surface will be covered in 3 months by a thin, smooth, glistening endothelium, free from excrescence formation and fibrin precipitation, extending over the groove and adjacent part of the suture ring. Thus the thicker fibrous covering over the suture ring will be connected with the microporous covering. This will prevent a thrombotic protrusion into the valve orifice with risk for emboli. As the Monostrut valve has been accepted by the Food and Drug Administration after 16 years of successful clinical use, the results achieved from this pilot study indicate the necessity of a multicenter study, the outcome of which could solve valve surgery problems, especially for young girls.

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REFERENCES

1. MacGregor DC, Pilliar RM, Wilson GJ, et al. Porous metal surfaces: a radical new concept in prosthetic heart valve design. *Trans Am Soc Artif Intern Organs* 1976;22:646-53.
2. Björk VO, Sternlieb JJ, Kaminsky DB. Optimal microporous surface for endothelialization of mitral valves in the blood stream. *Scand J Thorac Cardiovasc Surg* 1990;24:97-100.
3. Björk VO, Kaminsky DB. The five-year evaluation of a mechanical heart valve without anticoagulation in goats. *J Thorac Cardiovasc Surg* 1992;104:22-5.
4. Björk VO, Henze A, Lindblom D. The Monostrut strength. *Scand J Thorac Cardiovasc Surg* 1985;9:13-9.
5. Björk VO, Ribeiro A, Canetti M, Bomfim V. Mitral mechanical valve without long-term anticoagulation. *Scand J Thorac Cardiovasc Surg* 1994;28:19-24.

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A fatal mechanical disorder of the TCI HeartMate left ventricular assist system

To the Editor:

The HeartMate vented electric (VE) left ventricular assist system (LVAS) (TCI; Thermo Cardiosystems Inc, Woburn, Mass) has been used in more than 1400 patients worldwide and in 42 patients in our hospital since November 1995. We experienced a case of fatal mechanical disorder with this device, which required an emergency exchange of the LVAS. The patient was a 34-year-old man who had undergone implantation of the HeartMate VE LVAS because of dilative cardiomyopathy more than 1 year earlier. He was referred to us twice for

Fig 1. Clotted blood was seen in the whole LVAS motor chamber, which prevented the pump from working.