Discrete Subaortic Stenosis Complicated by Aortic Valvular Regurgitation
Clinical, Hemodynamic, and Pathologic Studies and the Results of Operative Treatment

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When the physician encounters a patient in whom the clinical examination, the electrocardiogram, and roentgenograms indicate the presence of combined aortic stenosis and regurgitation, he will usually attribute these findings to an aortic valve that has been rendered both stenotic and regurgitant by rheumatic valvulitis and its sequelae. Indeed, in the vast majority of patients, this clinicopathologic correlation will prove to be correct when the valve is examined at operation or autopsy. Recently, however, four interesting exceptions to this general rule were encountered in patients studied at the National Heart Institute. In each of them a congenital subaortic membrane was responsible for obstruction to left ventricular outflow, and the aortic valve had been rendered incompetent by bacterial endocarditis. In three of the patients operation was carried out, and the operative findings, the methods of surgical treatment, and the results of hemodynamic studies are presented. The fourth patient died before operation, and the necropsy finding provide information concerning the etiology of the anatomic malformations observed in this combination of congenital and acquired heart disease.

Clinical Summaries

Case 1

A. G. (no. 04-20-58) is a Peruvian housewife 44 years of age. A detailed medical history was not furnished by her referring physician, but she stated that she had had a heart murmur since childhood. Sixteen years before admission she was treated with penicillin for a prolonged febrile illness, during which she suddenly lost vision in her left eye. When admitted to the Institute in April 1962, she described chest pain and dyspnea on exertion and intermittent swelling of the ankles.

On examination, the heart was enlarged and the blood pressure was 130/70. A systolic thrill and a grade-V/VI ejection systolic murmur were present at the base of the heart and could be detected in the carotid arteries. A grade-II/VI blowing diastolic murmur was audible along the left sternal border. Visual acuity was markedly diminished in the left eye but the funduscopic examination revealed only some tortuosity of the arterioles. The electrocardiogram revealed left ventricular hypertrophy and frequent multifocal premature ventricular contractions; ST and T-wave abnormalities suggested a previous anterolateral myocardial infarction. Fluoroscopic and radiographic examinations demonstrated moderate generalized cardiac enlargement with particular prominence of the left atrium and left ventricle. There was no evidence of intracardiac calcification.

Right and transseptal left heart catheterizations were performed. The right ventricular pressure was 50/3 mm. Hg, and the mean left atrial pressure was 12 mm. Hg. The left ventricular pressure was 216/20 mm. Hg, and the brachial arterial pressure was 115/55 mm. Hg (fig. 1). An aortic regurgitation quantification test,1 the disappearance curve of I131 Diodrast injected into the left ventricle,2 and arterial indicator-dilution curves recorded after left ventricular injection (fig. 2) were all indicative of a moderate degree of aortic regurgitation.

When the aortic valve was exposed at operation all three of the leaflets were seen to be thickened but there was no commissural fusion. There was a circular perforation 3 mm. in diameter through the base of the left coronary leaflet. Immediately beneath the valve was a fibromuscular membrane, typical of the discrete form of congenital subaortic stenosis. The membrane was resected, and the
perforation in the valve was closed with two mattress sutures of fine silk placed through its rolled and fibrotic margins.

The patient made an uneventful recovery and when she returned for postoperative study 3 months later she was asymptomatic. Repeat left heart catheterization revealed a residual systolic gradient of 22 mm Hg (fig. 1). The brachial arterial diastolic pressure was 72 mm Hg and the contour of the left ventricular indicator-dilution curve was normal (fig. 2).

Case 2

T. D. (no. 04-75-48) is an 8-year-old schoolboy who first came to medical attention when he had two syncopal attacks 9 months before admission. At that time his physician noted a precordial systolic murmur and his heart was found to be enlarged by x-ray. Five months later he developed pneumococcal meningitis for which he was treated with penicillin. He was then apparently well until the month before admission, when he again became febrile, manifested severe congestive heart failure, and suddenly developed a right hemiparesis. Blood cultures at this time were sterile, but he was treated with antibiotics and later underwent cardiac catheterization. The pulmonary artery pressure was 55/32 mm Hg and the mean pulmonary arterial wedge pressure 32 mm Hg. At retrograde arterial catheterization the left ventricular pressure was 176/61 mm Hg and the central aortic pressure 118/63 mm Hg. A cineangiocardiogram, with injection at the aortic root, demonstrated massive aortic regurgitation and suggested the presence of discrete subaortic stenosis.

On admission to the Institute, January 16, 1963, the child was critically ill. There was a flaccid right hemiparesis, the liver was palpable 6 cm below the costal margin, and ascites was evident. The pulse was 120 and the blood pressure 118/58/40. Pistolshot sounds were audible over the femoral arteries. The heart was massively enlarged, both to palpation and by x-ray (fig. 3A). A grade-III/VI systolic murmur was audible at the aortic area and was referred to the neck. A grade-III/VI blowing diastolic murmur was heard along the left sternal border. The electrocardiogram revealed left ventricular hypertrophy.

Operation was carried out, as a semi-emergen-
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Radiographic appearance of the heart of patient T.D., preoperatively (A) and 7 months postoperatively (B).

Figure 3

Records of left ventricular (L.V.) and systemic arterial pressure obtained in patient T.D. before operation and at intervals afterward. Ao = central aorta; R.A. = radial artery; F.A. = femoral artery; B.A. = brachial artery.

Figure 4

Records of left ventricular (L.V.) and systemic arterial pressure obtained in patient T.D. before operation and at intervals afterward. Ao = central aorta; R.A. = radial artery; F.A. = femoral artery; B.A. = brachial artery.

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cy, on January 25, 1963. All of the cardiac chambers were grossly enlarged, and both systolic and diastolic thrills were palpable in the ascending aorta. Pressure measurements revealed the end-diastolic pressures in the left ventricle and aorta to be essentially identical (37 mm. Hg), and there was a systolic pressure gradient of similar magnitude between these areas (fig. 4).

The aortic valve was tricuspid. Two large perforations and several healed vegetations were present in the base of the noncoronary leaflet. The left coronary sinus of Valsalva was filled with vegetations and two perforations were found in this leaflet. The right coronary leaflet was thickened but otherwise normal. Beneath the valve was a typical discrete fibromuscular membrane, which was resected. The left and noncoronary valve leaflets were excised and replaced with prosthetic leaflets of Teflon. Intracardiac pressure measurements at the conclusion of the operation showed complete abolition of the systolic pressure gradient, a normal diastolic arterial pressure, and a reduced left ventricular end-diastolic pressure (fig. 4).

Assisted respiration was provided through a tracheostomy in the early postoperative period and the child made a slow but satisfactory recovery. His hemiparesis improved rapidly during a period of rehabilitation and physical therapy, and after 8 weeks he had regained use of his arm and could walk unassisted. At this time a left ventricular puncture showed a systolic gradient of 21 mm. Hg across the reconstructed valve and normal diastolic pressures in the left ventricle and femoral artery. Seven months after operation
at a repeat study a diastolic as well as a systolic murmur was audible. The valvular gradient and ventricular end-diastolic pressure were essentially unchanged. The arterial diastolic pressure was 50 mm. Hg (fig. 4). The heart had returned nearly to normal size.

Case 3

K. W. (no. 05-23-07) is a housewife 41 years of age. Since childhood she had been told of a heart murmur and she had had occasional syncopal attacks. In January 1963, she underwent excision of an aneurysm and shortly thereafter developed bacterial endocarditis with alpha streptococcus. The infection was eradicated by 4 weeks of penicillin therapy, but during the period of treatment an aortic diastolic murmur became audible.

She was admitted to the National Heart Institute in September 1963, with principal symp-
January 24, 1964, and was noted to be thin and pale but not acutely ill. The blood pressure was 120/70, the pulse was 120 and regular. Two white-centered pharyngeal petechiae were noted, and rales were heard at the bases of both lungs. The liver was felt three fingerbreadths below the right costal margin, but the spleen was not palpable. The heart was enlarged and a left ventricular heave was present. A systolic thrill and a grade-III/VI systolic ejection murmur were present at the base of the heart and were transmitted to the neck. A grade-II/VI diastolic blowing murmur was heard along the left sternal border. Laboratory examinations revealed the white-blood-cell count to be 13,700/mm³, the hematocrit level 34 per cent, and the hemoglobin, 10.2 Gm./100 ml. The electrocardiogram showed sinus tachycardia, left ventricular hypertrophy, and marked clockwise rotation. The patient was febrile and remained so during his brief hospitalization.

Eighteen hours after admission the patient suddenly developed a supraventricular tachycardia, and pulmonary edema swiftly followed. Despite the use of positive pressure oxygen, morphine, and...
peripheral tourniquets, cardiac arrest occurred and resuscitative efforts were unsuccessful. The pertinent findings at necropsy are illustrated in figures 7, 8, and 9.

**Discussion**

Only recently has it become apparent that the incidence of bacterial endocarditis is ex-

![Figure 8](http://circ.ahajournals.org/lookup/fig/300/300/168)

**Figure 8**

The interior of the heart of patient J.M. Upper left. The left ventricle (L.V.), the discrete subvalvular membrane responsible for stenosis (between the arrows), and ascending aorta are opened. Vegetation covers the aortic valve cusps, the subvalvular membrane, and the ventricular surface of the anterior leaflet of the mitral valve (A.L.). Several perforations are present in the aortic valve cusps. The ragged depressions in the anterior mitral leaflet and ascending aorta are mycotic aneurysms. The posterior mitral leaflet (P.L.) is normal. Upper right. This view is similar to the upper left one, but the anterolateral portions of the left ventricle (L.V.), anterior mitral leaflet (A.L.), aortic valve, and ascending aorta have been removed. The discrete obstruction in the left ventricular outflow tract, with its relation to surrounding structures, is again shown. The subaortic membrane is indicated by arrows, and there is marked endocardial fibrous thickening below it. P.T., pulmonary trunk; L.A., left atrium. Lower left. The left atrium (L.A.) and the left ventricle (L.V.) are opened. The two prominent bulges in the anterior mitral leaflet (arrows) are the mycotic aneurysms, seen from the ventricular aspect in the upper figures. There is marked left ventricular hypertrophy. Lower right. The discrete subvalvular area of obstruction is shown from below. A.L., anterior mitral leaflet. The insert between the upper and lower right photographs shows the aortic valve as seen from above.
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ceasionally high in patients with discrete subaortic stenosis. In the collected series reported by Fontana and Edwards, for example, endocarditis or its sequelae were evident at autopsy in 13 of 29 patients. The infectious process usually originates on the aortic valve, rather than on the obstructing membrane beneath it. Although the valve is normal at birth, the high velocity jet of blood coming through the stenotic subvalvular orifice impinges upon it during each systole. The effect of this trauma is to thicken and distort the valve, a finding almost universally noted at operation in patients who have not had endocarditis. The structural changes in the valve account for the diastolic murmurs frequently heard in patients with discrete subaortic stenosis and apparently also render the valve susceptible to infection. The sequence of pathologic events suggested by the anatomic findings in patient J.M. is illustrated in figure 10.

The clinical findings in each of the four patients described above suggested the combined congenital and acquired nature of the disease. None had had rheumatic fever, and all had had murmurs since childhood. Each patient had had bacterial endocarditis and in two the onset of aortic regurgitation during the infection was documented. The syncopal attacks experienced by T.D. and K.W. were certainly compatible with congenital

**Figure 9**

Photomicrographs of sections through the area of discrete subvalvular stenosis in patient J.M. Left. This section demonstrates the relationship of the discrete subvalvular membrane to aortic valve, ventricular wall, and right atrium. Right. This section demonstrates the relationship of the discrete subvalvular obstruction to the anterior mitral leaflet. The band is located directly opposite the annulus fibrosus of the mitral valve, and is continuous with the left atrial myocardium. One mycotic aneurysm is located in the mitral valve below the obstruction and a second one is evident in the ascending aorta. The media of the ascending aorta is completely disrupted by the aortic aneurysm. The deposits of calcium on the aortic valve cusps are entirely on their ventricular aspects, the sites of jet impact. Verhoeff-Van Gieson elastic-tissue stain (left) and hematoxylin and eosin stain (right); original magnification of each section × 3.2.
obstruction to left ventricular outflow. In adult patients with valvular aortic stenosis, whether congenital or acquired, calcification of the aortic valve and dilatation of the ascending aorta are almost always evident radiographically. The absence of these findings in all of the adult patients was, therefore, strong evidence in favor of subvalvular stenosis.

The preoperative hemodynamic studies in patients T.D. and K.W. established the correct diagnosis. In both, sequential pressure tracings and selective cathangiography proved that the obstructive lesion was within the left ventricle. In these two patients aortic regurgitation was extremely severe, since the diastolic pressures in the left ventricle and aorta were identical. In patient G. A., on the other hand, regurgitation through the single small valvular perforation was of lesser hemodynamic significance. On the basis of the present experience it would appear that retrograde arterial left heart catheterization and selective angiocardiography or aortography are the diagnostic methods most useful in distinguishing combined subaortic stenosis and valvular aortic regurgitation from the more common congenital and acquired malformations involving the aortic valve alone.

The methods employed in this clinic for exposing the aortic valve and left ventricular outflow tract at operation have been described elsewhere in detail.10, 11 The essential features are cardiopulmonary bypass at a flow rate of 2 L.min./M.2 BSA, moderate hypothermia, and coronary artery perfusion during the period that the aorta is open. The typical form of congenital discrete subaortic stenosis was present in each of the three patients described. This obstruction consists of a crescent-shaped ridge of fibrous tissue which occupies the anterior two thirds of the outflow tract and which is in continuity with both the aortic and mitral valves. The membrane may be easily exposed and excised, but care must be taken to avoid injury to the adjacent portions of the valves.10

When the aortic valve has been rendered regurgitant by endocarditis, the technics utilized in restoring competence depend upon the specific anatomic deformities encountered. When a single leaflet perforation is found in an otherwise normal valve, as in patient G. A., closure of the perforation by direct suture, or the insertion of a patch of prosthetic fabric, will usually restore satisfactory function.12 When the valve is more extensively damaged, however, total valve re-

Figure 10

Diagram of aortic-valvular region of patient J.M., illustrating the course of the pathologic process suggested by the necropsy findings. The left diagram shows the discrete subvalvular obstruction before the development of bacterial endocarditis. At this time the valve was traumatized by the jet of blood from below. The central diagram depicts the initial formation of bacterial vegetations, exclusively on the aortic valve cusps. As this process progressed, the cusps ruptured (right diagram); the infection then extended to the discrete subvalvular fibrous band and anterior mitral leaflet (A.L.), where a mycotic aneurysm formed, immediately below the membrane where systolic pressure was highest. A second aneurysm in the wall of the ascending aorta resulted from the effects of a systolic jet through the valve. L.A., left atrium; V.S., ventricular septum; L.V., left ventricle.

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placement is indicated. The Starr-Edwards aortic valve, which was utilized in patient K. W., is now employed in this clinic whenever possible. In patient T. D. a Starr-Edwards valve could not be inserted because of the diminutive size of the aortic root, and the two diseased leaflets were replaced with prosthetic ones made of Teflon fabric. The function of his reconstructed valve is satisfactory thus far, but other experiences with Teflon aortic leaflets indicate that this favorable hemodynamic result will not be permanent. It is to be hoped, however, that if significant aortic regurgitation recurs, the child’s aorta will have become large enough to permit the insertion of a more satisfactory prosthesis.

In conclusion, it must be emphasized that when operative treatment is indicated in a patient who has had bacterial endocarditis, the procedure must be deferred for a period after cessation of treatment sufficiently long to insure that the infection has been eradicated. All intracardiac operations involve the placement of foreign materials into the heart or great vessels, and in a septic field these materials will almost certainly become foci for a continuing and ultimately fatal infection.

Summary

Four patients are described in whom combined aortic stenosis and regurgitation was evident on examination. In each of them obstruction to left ventricular outflow was shown to be due to congenital subaortic stenosis, and aortic regurgitation resulted from the sequelae of bacterial endocarditis. The presence of this unusual combination of congenital and acquired malformations was suggested by certain clinical findings, and results of the preoperative hemodynamic and angiographic studies that established the diagnosis are presented.

In three patients the subaortic membrane was resected, and aortic regurgitation was corrected by reconstruction or replacement of the aortic valve. All of the patients evidenced striking clinical improvement after operation, confirmed by the results of postoperative hemodynamic assessments. A fourth patient died before operation; the pathologic findings are presented in detail.

References

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