The Importance of the Myocardial Factor in the Surgical Treatment of Rheumatic Aortic Stenosis

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Although major advances in the field of medicine and surgery frequently develop with astonishing rapidity, painstaking years of research usually precede the final achievement. Subsequently, a good deal of time must be spent to elucidate those factors which in some way might influence the attainment of an ideal clinical result.

The development of techniques for the surgical treatment of aortic stenosis adheres to this general pattern. The continued interest in these methods is explicable on the basis of the generally satisfactory results obtained by aortic commissurotomy. It also necessitates detailed inquiry into other facets of this important problem.

Preliminary steps along these lines have been made. One review1 outlined the importance of aortic valve calcification and leaflet mobility in patients undergoing commissurotomy while another study2 considered the prognostic importance of left bundle branch block in a smaller group of cases.

The present article indicates the importance of the myocardial factor in the treatment of rheumatic aortic stenosis by summarizing our experiences with patients who had considerable left ventricular enlargement and who were subjected to operation.

Methods and Material

The records, including roentgenograms, of 196 patients who had an aortic commissurotomy performed during the interval from April, 1952 until July, 1956 were reviewed. Of these, 26 cases were selected for the present study. All in this group had radiographic evidence of massive left ventricular enlargement (3 plus or greater, based on a range of 0 to 4 plus). In appraising heart size, the important factors of body weight, height, surface area, age, and sex were considered. It was recognized that there are objections to all forms of cardiac measurement especially when studies are made in only one dimension.

Each patient had major aortic stenosis alone or in combination with an insignificant degree of aortic regurgitation. Eleven were operated on by the transventricular and 14 by the transaortic approach. One had an aortic commissurotomy performed by an open technique employing circulatory by-pass and controlled cardiac arrest.

Preoperatively, right heart catheterization was performed in eight cases and it was repeated postoperatively in two. Combined heart catheteriza-
tion was carried out before and after surgery in one case according to
techniques previously described.3

Results

1. Hospital Course:

Of the 11 patients operated on by the transventricular approach, three
(27 per cent) died at the time of operation or in the immediate postopera-
tive period. There were 4 (28 per cent) hospital deaths among the 14 sub-
jected to transaortic commissurotomy. One survived open heart surgery.

Cardiac arrest or ventricular fibrillation accounted for four of the
deaths at the time of surgery. In one case ventricular standstill was pre-
cipitated by the inadvertent technical mishap in which a coronary vessel
was injured. Miscellaneous causes of death included heart failure, sub-
acute bacterial endocarditis, and the production of dynamic aortic regurgi-
tation.

2. Follow up Review:

There were six (60 per cent) late deaths in the follow-up group of pa-
tients operated on by the transaortic approach during an interval extend-
ing up to four years after surgery. Five of these were due to cardiac
failure while one was presumably the result of cardiac arrest.

There were six (75 per cent) late deaths in the group operated by the
transventricular approach during an interval extending up to four and
one-half years after surgery. Half of these were due to heart failure while
the remainder were due to unknown causes or cardiac arrest.

Of the late deaths seven occurred within one year following the aortic
commissurotomy.

A total of seven surviving patients have been followed for a period
extending from six months to four years. All of these patients were
clinically improved.

The total mortality rate (hospital and late deaths) for all patients oper-
ated on for aortic stenosis with massive left ventricles was 73 per cent.

Discussion

In early stages of aortic stenosis a greater stroke output is accomplished by the
combination of a more forceful myocardial contraction and a more prolonged systolic
ejection period. With greater degrees of stenosis, the systolic pressure generated by
the left heart muscle must exceed that in the central aorta to insure an adequate
cardiac output. The presence of this chronic pressure load leads to myocardial hyper-
trophy. The myocardial fibers must increase in size in order to generate the tension
needed to produce high intraventricular pressures. In the advanced stages of the disease
dilatation becomes relatively more significant as the left ventricular chamber becomes
massive in size.

The dynamic properties of heart muscle are not completely understood4-6 although
important advances have been made. Most agree, however, that the larger the heart,
the less its mechanical efficiency and the less the ability to perform useful work.7

An enlarged heart may be associated with specific chemical imbalances. These may
take the form of deficiencies in metabolites needed to produce high energy phosphate
as well as the muscle protein needed for contraction.8

It is readily apparent that there is no exact correlation between the degree of load
placed on a heart chamber and the extent of the cardiac enlargement that results. In a
series of patients with rheumatic aortic stenosis who have undergone combined cardiac
catheterization, markedly narrowed aortic valve areas were noted in patients with both
small and large hearts.9

One of the known limiting factors in cardiac hypertrophy appears to be the coronary
vascular bed, which remains unchanged in the face of an increased muscle mass.10 The
difficulty in perfusing these vessels becomes more important in aortic stenosis where
special hemodynamic situations prevail. Left heart catheterization studies have shown
a tendency for elevation of the diastolic pressure in patients with far advanced aortic
stenosis in the absence of congestive heart failure. This has been related to the pressure-volume relations of the left heart chamber. This factor, combined with the lengthening of the duration of systolic ejection, diminishes the period of diastole with consequent impairment of coronary perfusion. While most of the coronary flow occurs in diastole, some takes place during systole. This flow is seriously interfered with in aortic stenosis. The perfusing pressure on the aortic side of the valve is diminished, while the high intraventricular pressure decreases flow by limiting venous drainage. It is also possible that the abrupt change in flow across the stenosis orifice causes a fall in lateral pressure with production of a Venturi effect, limiting coronary filling. The failure of the myocardium in aortic stenosis then may be considered the direct result of coronary insufficiency.

Attempts to define this myocardial factor, non-specific and variable as it is, have been made by two groups. Hecht, in a review of patients with chronic cor pulmonale, noted that patients with chronic lung disease and pulmonary hypertension develop congestive heart failure only with advancing years. In such cases it is apparent that at least one factor, coronary atherosclerosis, determines how well the myocardium can tolerate the added load produced by elevation of pressure within the pulmonary circuit.

In rheumatic heart disease Harvey et al. have studied a special aspect of this myocardial factor. They observed a small group of patients with mitral stenosis, who, in the absence of clinical failure, had little or no pulmonary hypertension at rest. Yet, there was no appreciable increase in cardiac output on exercise. More than half of this group had low cardiac outputs at rest. They concluded that these patients had low cardiac output due to myocardial insufficiency rather than mechanical block. It was their impression that the performance of a mitral commissurotomy is of little value in these patients.

On the other hand, Dickens and her associates employing the technique of combined heart catheterization, noted widely varying degrees of pulmonary hypertension and cardiac output in patients with similar mitral valve areas. They interpreted their data as indicating little upon which to predict the result of the surgery.

In our group of cases with aortic stenosis and massive cardiac enlargement, right heart catheterization proved of little value in the identification of a common physiological substrate. The resting cardiac index was below normal in five of the eight cases and ranged from 1.8 to 2.9 L/M² B.S.A. The pulmonary artery pressures were elevated

FIGURE 1: Photomicrograph magnified to demonstrate an area of necrosis in left ventricle of a patient with massive hypertrophy. Note secondary vascular and fibroblastic proliferation. The left coronary vessel showed minimal arteriosclerosis.
in three, and in one patient with repeated bouts of left heart failure it was recorded
at 110 mm. of Hg. (systolic).

Two of these cases were studied postoperatively and, in one, the resting cardiac index
rose by 50 per cent.

In the one patient studied before and after surgery by combined heart catheterization,
the systolic ejection gradient across the aortic valve was eliminated completely. This
obsetvation strongly suggests that satisfactory objective alterations can be accomplished
even in the presence of significant cardiac enlargement.

Post-mortem examination was obtained in a few cases. The pathological changes in
the heart muscle itself were not specific. Scattered areas of fibrosis were common, and
focal necrosis and myomataclia were occasionally demonstrated (Fig. 1). The incidence
of coronary artery disease did not appear to be increased. When present, it often precipi-
tated an accelerated devolutionary phase of the disease.

With knowledge of the detrimental effects of massive ventricular hypertrophy, it was
interesting to note the negligible difference in mortality rate between those operated
on by the transaortic approach and those subjected to transventricular aortic commis-
surotomy. In addition, the mortality rate in larger series of 170 patients with smaller
(6-2 plus) hearts was only slightly less than in the group with massive left ventricles.
(Table 1).*

While patients with large hearts tolerated cardiac surgery almost as well as the con-
trol group, they generally did poorly postoperatively. Nearly six out of 10 were dead
within five years and 68 per cent expired within 12 months after aortic commissurotomy.
On the other hand in the follow-up group of 134 patients with smaller hearts only two
out of 10 had died within a comparable period of time.

The total mortality rate (hospital and late deaths) was two times greater in
patients with massive left ventricles.

Despite the fact that an occasional patient in this special group did improve after
aortic commissurotomy, it seems best to consider patients with massive left ventricles
as poor candidates for aortic commissurotomy. It is recognized that mistaken evalua-
tions will still be made in the absence of specialized diagnostic procedures capable of
identifying and approximating the severity of the myocardial factor. A study of
left ventricular hemodynamic data in patients of this type is now in progress. Also, this
analysis may not hold in cases where aortic commissurotomy is carried out by an
open technique.

CONCLUSIONS

1. The importance of the "myocardial factor" is considered in a review of 26 pa-
tients with massive left ventricular hypertrophy undergoing aortic commissurotomy.

2. The hospital mortality rate was 28 per cent despite the closed technique employed.
This was slightly higher than the mortality rate of 21 per cent in a group of 170
patients with aortic stenosis and small left ventricles.

3. A follow up of 19 cases who survived surgery revealed that 63 per cent had ex-
pired as compared to 23 per cent in a group of 134 cases with small left ventricles.
The total mortality was 73 per cent in those with massive left ventricles as compared
to 39 per cent in the control group.

4. The various limiting factors in cardiac hypertrophy are discussed, and the cardiac
catheterization data in nine patients is reviewed. In one case studied by left heart
catheterization a significant drop in the systolic gradient across the aortic valve was
recorded.

5. It is concluded that this group generally represents poor candidates for the per-
formance of an aortic commissurotomy, especially if a closed technique is employed.

CONCLUSIONES

1. La importancia del "factor miocárdico" se ha considerado en 26 enfermos con
hipertrofia ventricular izquierda voluminosa que sufrieron la comisurotomía aórtica.

2. La mortalidad en el hospital fue de 28 por ciento a pesar de la técnica cerrada
empleada. Esta fue ligeramente más alta que la mortalidad de 21 por ciento en un
grupo de 170 enfermos con estenosis aórtica y pequeños ventrículos izquierdos.

3. El seguimiento de 19 casos de estenosis aórtica que sobrevivieron, reveló que el
63 por ciento habían muerto comparado con 23 por ciento del grupo de 134 vasos con
ventrículos pequeños.
La mortalidad total fue 73 por ciento en los que tenían ventrículos izquierdo con 
gran hipertrofia comparada con 39 porciento del grupo de control.
4. Se discurre sobre los factores limitantes en el caso de hipertrofia cardiaca y se
revisan los datos de la cateterización cardiaca en 9 casos. En un caso estudiado por 
cateterización del corazón izquierdo, se registró una caída significativa del gradiente 
sistólico a través de la válvula aórtica.
5. Se concluye que este grupo generalmente es de candidatos malos para la comisu-
rotomía aórtica en particular si se emplea la técnica cerrada.

ZUSAMMENFASSUNGEN
1. Die Bedeutung des "Myocard-Factors" wird einer Analyse unterzogen in einer 
Übersicht von 26 Kranken mit starker links-seitiger Kammerhyperthrophie, die sich
einer Aorten-Kommissurotomie unterzogen.
2. Die Ziffer für die Krankenhaussterblichkeit betrug 28% trotz der angewandten 
geschlossenen Technik. Sie war etwas höher als die Sterblichkeitsziffer von 21% bei
einer Gruppe von 170 Klinischen mit Aortenstenose und kleinen linken Kammern.
3. Eine Nachuntersuchung von 19 Fällen, die die Operation überlebten, ergab, dass
63% gestorben waren im Vergleich zu 23% in einer Gruppe von 134 Kranken mit
kleinen linken Ventrikel. Die Gesamt mortalität betrug 73% bei solchen mit starken
linken Kammern im Vergleich zu 39% in der Kontrollgruppe.
4. Die verschiedenen beschränkenden Faktoren bei der Herzhyperthrophie werden 
besprochen und die Werte bei Herzkatheterisierung von 9 Kranken durchgeführt. In
einem Fall, der mittels Katheterisierung des linken Herzens untersucht worden war,
war ein beträchtlicher Abfall im systolischen Druckgefälle quer durch die Aorten-
kappen zu verzeichnen.
5. Es wird gefolgert, dass diese Gruppe ein schlechteres Ausgangsmaterial bietet 
für die Vornahme einer Aorten-Kommissurotomie, besonders bei Verwendung der ge-
schlossenen Technik.

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