Commissurotomy for Rheumatic Aortic Stenosis

I. Surgery

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As long as the middle of 1949 it had been demonstrated by the senior author that any blunt dilating mechanism applied within the stenotic aortic orifice would, upon expansion, force the separation of one or more of the fused commissures. Thus the diminutive valve orifice could be enlarged without the creation of additional insufficiency and with the restoration of such part of the original valve function as the pathologic distortion of the leaflets would permit. In other words the principles and effectiveness of such an aortic commissurotomy would be comparable to those of the similarly named operation for mitral stenosis. It has remained for us finally to develop an instrument and a technic capable of implementing these concepts, and this has at last been accomplished.

This is the first of three articles dealing respectively with (1) the basic concept and methods of performing aortic commissurotomy surgically, (2) comparison of physiologic abnormalities noted preoperatively with the changes produced by aortic surgery, and (3) the selection, medical management, and clinical results obtained by aortic commissurotomy.

Rheumatic involvement of the aortic valve is second in frequency only to mitral valve involvement. In both instances the pathologic developments are parallel and primarily tend to produce stenosis. Early appearance of rheumatic vegetations along the lines of valve closure is followed by fibrosis along the free valve edges and for a variable distance into the adjacent tissue. Commisural fusion begins peripherally (toward the mitral or aortic annulus) and progresses centripetally. This process eventually reduces the mitral orifice to a very small segment of its original semi-circular orificial arc, and reduces the aortic orifice to a tiny triangular central passageway (figs. 1 and 2). In either valve the process may be asymmetric leading perhaps to eccentric placement of the mitral opening, or to bicuspid transformation of the aortic valve or orifice (figs. 3 and 4). Subsequent calcific deposition may further deform or distort the valvular elements greatly.

While mitral valve stenosis is considered to be nearly always the end result of rheumatic involvement, many contend that aortic stenosis is usually arteriosclerotic in origin. Others, notably Cabot,1a Karsner and Koletsy,1b and McGinn and Whitea feel that aortic stenosis is nearly always of rheumatic origin. The authors would like to present the question of the etiology of aortic stenosis as follows: When aortic stenosis is associated with a known rheumatic mitral valve lesion, as it has been in more than one-half of the cases which we have subjected to aortic surgery, it must be presumed that the aortic lesion is also rheumatic. When a very similar type of aortic lesion (with well marked commissural fusion) is seen without coexisting mitral disease, we believe that it must also be presumed to be of rheumatic origin. On this basis of reasoning we feel that the vast majority of cases of clinical aortic stenosis must be considered rheumatic.

This is not an academic question since the presence or absence of commissural fusion, so characteristic of rheumatic aortic stenosis, is

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the most important single element determining the type and effectiveness of possible corrective valve surgery. The classic congenital case of aortic stenosis is characterized by a funicular or megaphone-like valve structure without evidence of pre-existing commissures (fig. 5). The bicuspid aortic valve is also usually of congenital origin. It may become the site of a superimposed rheumatic stenosis (fig. 6). While such cases certainly present fused commissures and might well be helped by surgical commissurotomy, it would seem that the instrumentation which would here be appropriate would be entirely different from that which has proven effective in the tricommissured valve (fig. 7a and b).

The arteriosclerotic form of aortic stenosis is characterized by a hardening of the valve leaflets and by deposition of calcium salts. There is characteristically no commissural fusion. In such cases the procedure of commissurotomy would seem to be most inappropriate or even impossible. Indeed any dilating or separating mechanism applied within the lumen of the aortic orifice in such a case will only serve to enlarge the opening momentarily. The semirigid valvular structures tend to spring back into their previous position as soon as the instrument is removed.
Commissurotomy for Rheumatic Aortic Stenosis

Similarly, subacute (or acute) bacterial endocarditis does not characteristically tend to produce valvular commissural fusion. However, because of its known tendency to become superimposed upon a valve previously damaged by rheumatic disease, one may expect to observe combined cases of rheumatic and bacterial disease. In them, when commissural fusion exists, the possibility of successful application of the principle of commissurotomy also exists, once the active infection has been thoroughly suppressed by antibiotics.

Since its first presentation in June, 1948, the principle of commissurotomy has been successfully applied in cases of mitral stenosis to restore both an adequate valvular orifice and a normal type of valvular function. It still remains the accepted method of correcting this condition surgically. In 1950, commissurotomy was successfully employed in the treatment of rheumatic tricuspid stenosis.\(^1\)\(^2\)

The principle of aortic instrumental commissurotomy has been presented as early as 1950,\(^2\) and an approach through the right common carotid artery (retrograde fashion) has been described. Unfortunately, both that instrument and that approach have since proven faulty. Both have subsequently been greatly modified.

Since the concept of commissurotomy implies a fusion of pre-existing commissures which may be more or less accurately re-established by separating the valve into its individual anatomic components, its most logical application would seem to be in rheumatic stenotic valvular lesions. While individual cases of congenital, arteriosclerotic, or bacterial aortic stenosis may prove suitable for commissurotomy, the majority will not be amenable to this technic. Mixed cases with both rheumatic and other valvular lesions will, of course, frequently respond favorably to commissural separation.

It must be emphasized that the clinical effectiveness of any commissurotomy technic depends both upon the amount of residual mobility or flexibility which remains in the valvular elements and the valve ring and upon the amount of myocardial vigor and integrity which is retained or can be restored. Both of these considerations suggest that one must not expect great clinical improvement in terminal or near-terminal cases. Our best results can be expected in cases with extensive early commissural fusion, before subsequent extreme distortion and degeneration of the valvular components permanently remove the possibility of return of appreciable valve function. It also seems probable that early mobilization of the fused valve commissures would tend to prevent the development of certain degenerative processes such as extensive calcific deposition upon the fused and immobile valve leaflets.

Efforts to correct aortic stenosis surgically by commissurotomy were maintained during 1950 and 1951. On April 4, 1952, the modern aortic dilator* became available to us. By that time, a reasonably satisfactory transventricular approach to the aortic valve had been de-

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veloped. The incorporation of the olivary-tipped guide wire or finder (H. P. Larzelere) has proven to be an invaluable addition to the instrument, since it largely obviates the otherwise considerable risk of producing a false passage through the back of the heart. The description of this instrument and our early experience in its employment by the transventricular route have been presented elsewhere.6-8

The ability of the triradiate dilating head, which is triangular on cross-section both in the closed and open position, to adjust automatically (by rotation on a swivel mechanism) to the outline of the roughly triangular residual aortic orifice ensures a proper alinement of each wedge-like dilating bar against the appropriate fused commissure. The tendency of the adherent or fused commissures to separate upon expanding pressure is thus exaggerated. Frequently all three commissures will become extensively separated, but at least one or two will invariably part (fig. 8 a and b).

Thus, a purely instrumental aortic commissurotomy can be accomplished by transventricular passage of the instrument without direct palpation of the valve or accurate visual or digital guidance of the commissurotomy. The immediate surgical results obtained after one year's experience in the use of this instrument by this method are shown in table 1. Physiologic and clinical results obtained will appear in the subsequent papers of this series.

The overall operative mortality in 62 patients operated upon by this technic has been 17.7 per cent, which seems to us to be unduly high even though many of these patients were very ill or even nearly terminal. More than one-half of the cases in this series have been complicated by the coexistence of mitral valve lesions. These associated lesions have been simultaneously subjected to appropriate cor-

![Fig. 8.](http://circ.ahajournals.org/)

(a) The dilating head in position in the stenosed aortic valve showing the guide wire extending beyond into the aorta. Purse string at the site of entrance through the left ventricular wall for control of bleeding. (b) The dilating head expanded showing the triradiate bars separating the aortic valvular commissures.
The possible differences in the aortic valve lesions might relate to the presence or absence of commissural fusion (etiologic differences), or to the severity of the stenosis. While a patient with both aortic and mitral stenotic lesions may be presumed to have rheumatic commissural fusion of both valves, the patient with only an aortic lesion may not be rheumatic at all. Therefore, the aortic valve may not present commissural fusion and may be completely unsuitable for the surgical technic contemplated. Three of our cases of isolated aortic disease included in this series were considered to be of congenital origin. It is noteworthy that, postoperatively, two of them presented evidence of a created aortic insufficiency. Only two other patients in the entire series of 62, showed a new or increased element of aortic insufficiency postoperatively. It might seem reasonable to presume that when the stenotic lesion of a single valve has brought an patient to his knees, it should be logically a tighter obstruction than that found in either of the two affected valves in a bivalvular case. Hence, one might hypothesize that the very tight univalvular lesion would offer greater surgical technical difficulties and would imply a greater chance of production of ventricular arrhythmias or other disturbances.

More likely, in the specific problem of coexisting aortic and mitral stenosis, the latter lesion prevents ready filling or at least overfilling of the left ventricular chamber and so protects the left ventricle from the worst effects of severe aortic obstruction. Examination of the heart with isolated aortic stenosis reveals the left ventricular wall to be thickened and hypertrophied. There is little or no dilatation of the ventricular chamber. The wall of the hypertrophied left ventricle is frequently very soft and “cheesy” so that properly applied sutures tend to cut through. This undoubtedly represents a form of myocardial degeneration, probably related to the prolonged “isometric” type of contraction necessary to force the ventricular contents through the obstructed aortic orifice. During surgery such a degenerated, hypertrophied ventricle frequently appears to be hyperirritable, manifesting runs of ventricular extrasystoles at the slightest stimulation.

Since there exists a state of relative coronary insufficiency in these cases, because of the existence of the great hypertrophic muscle

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**TABLE 1.—Immediate Surgical Results of Commissurotomy with Aortic Dilators, Using Transventricular Approach, in 62 Cases**

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. Cases</th>
<th>Early Deaths</th>
<th>Operative Mortality %</th>
<th>Late Deaths</th>
<th>Insuff. Created or Increased</th>
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</thead>
<tbody>
<tr>
<td>Univalvular (Aortic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Pure AS ......</td>
<td>15</td>
<td>3</td>
<td>20.0</td>
<td>0</td>
<td>3*</td>
</tr>
<tr>
<td>b) AS &amp; AI ......</td>
<td>12</td>
<td>3</td>
<td>25.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total ...........</td>
<td>27</td>
<td>6</td>
<td>22.2</td>
<td>0</td>
<td>3*</td>
</tr>
<tr>
<td>Multivalvular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) AS &amp; MS ......</td>
<td>9</td>
<td>1</td>
<td>11.1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>b) AS, AI, MS ...</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c) AS, AI, MS, MI</td>
<td>13</td>
<td>3</td>
<td>23.0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>d) AS, MI .......</td>
<td>3</td>
<td>1</td>
<td>33.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e) AS, MS, MI ...</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total ...........</td>
<td>35</td>
<td>5</td>
<td>14.3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Grand Total ......</td>
<td>62</td>
<td>11</td>
<td>17.7</td>
<td>2</td>
<td>4</td>
</tr>
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</table>

AI—Not dynamic.
* Two cases were congenital aortic stenosis.
Table 2.—Analysis of Cause of the 13 Deaths Occurring in 62 Cases of Aortic Stenosis Subjected to Commissurotomy with Aortic Dilator

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Vent. Fib. during operation</th>
<th>Vent. Fib. after operation</th>
<th>Hemorrhage during operation</th>
<th>Hemorrhage after operation</th>
<th>Pulmonary Embolus</th>
<th>Left Vent. Failure</th>
<th>Acute Right Vent. Failure</th>
<th>Increased AI due to Operation</th>
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</thead>
<tbody>
<tr>
<td>Univalvular</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>a) Pure AS</td>
<td>2</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>b) AS &amp; AI</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Multivalvular</td>
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<td></td>
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<tr>
<td>a) AS &amp; MS</td>
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<td></td>
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<tr>
<td>b) AS, AI, MS</td>
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<td></td>
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<tr>
<td>c) AS, AI, MS, MI</td>
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<td>d) AS, MI</td>
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<td>e) AS, AI, MI</td>
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<td></td>
<td></td>
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<tr>
<td>f) AS, MS, MI</td>
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</tr>
</tbody>
</table>

* Late death—4 mos. p.o.  
† Late death—4 weeks p.o.  
‡ 2 hrs. p.o.  
§ ½ hr. p.o.  
¶ 13 hrs. p.o.

mass in the presence of a low mean aortic pressure, one may assume that this degenerated, hypoxic myocardium should be particularly predisposed to the development of ventricular fibrillation. The depression of anesthesia and surgery, and the creation of a suitable trigger mechanism by the incising, manipulating, and suturing of the left ventricle would seem an ideal combination to precipitate this usually fatal arrhythmia. Reference to table 2 reveals that of six deaths occurring in the 27 cases of isolated aortic disease, five (83 per cent) were due or presumed to be due to ventricular fibrillation. One other case in this group was successfully defibrillated by massage and electric counter-shock. Manual cardiac “massage” has been found to be most unsatisfactory in these cases because the small left ventricular chamber and the very thick walls make it difficult to expel much blood from the heart manually and hence to produce an adequate output. It is also noteworthy that in one case in this group hemostatic suturing of the incision in the soft left ventricle was extremely unsatisfactory and led to death from ventricular hemorrhage several hours later. Both this ready tendency to irreversible ventricular fibrillation and the uncertainty of adequate hemostasis argue against the use of the transventricular approach to isolated aortic stenotic lesions.

On the other hand, in cases with both aortic and mitral stenosis the left ventricle is usually small, resembling that seen in isolated mitral stenosis. The myocardium of the left ventricle in these cases is characteristically firm and healthy to touch. Sutures hold well, and ventricular extrasystoles are infrequent during their application. These ventricles do not readily fibrillate even during the passage and manipulations of the dilating instrument. If ventricular fibrillation does occur in these cases (as in case F. K.), once both valvular obstructions have been relieved, rhythmic manual compression is very effective in establishing a good cardiac output, and defibrillation by countershock is readily accomplished. It is noteworthy that only one death (6.3 per cent) occurred in 16 patients (table 1) with simultaneously operated combined aortic stenosis and mitral stenosis (with or without associated insignificant aortic insufficiency), the lowest mortality obtained in any group in this operated series. It would seem that the transventricular approach to the aortic valve had, in this group, proved most satisfactory. The thoracic incision here employed (posterolateral approach through the fifth or sixth left intercostal space) fortunately is equally satisfactory for the performance of a simultaneous mitral commissurotomy.

In patients with coexisting aortic stenosis and serious mitral insufficiency the left ventricle is both hypertrophied and dilated. How-
COMMISSUROTOMY FOR RHEUMATIC AORTIC STENOSIS

ever, its general muscular firmness and tone seem better than that found in isolated aortic stenosis. In many of these the mitral insufficiency is of great magnitude and is unassociated with mitral stenosis. We believe it is often mainly related to over-stretching or dilatation of the mitral annulus, a result of the enlargement of the left ventricle and the great increase in the intraventricular pressures.

Surgical correction of the incompetent mitral valve by suturing the leaflets with a pericardial strip is, in itself, an operation of great magnitude, which in a series of 80 cases has been associated, in our hands, with a 25 per cent mortality. While this technic was used only in three cases in this series, along with simultaneous aortic commissurotomy, with two deaths, it seems probable that such combined surgery always will be associated inherently with a high operative mortality.

It would seem safer to stage these operations, correcting the aortic stenosis at the first stage. Should the resultant fall in left intraventricular pressure, or subsequent contraction of the mitral annulus lead to improvement in the mitral insufficiency, it might not prove necessary to perform a subsequent mitral suturing operation.

Because of the obvious dangers and difficulties associated with the transventricular approach in certain cases, we have considered other possible approaches to the aortic valve, preferably one permitting digital examination of the valve and tactile guidance of the instrumentation. The Ramirez maneuver, in which the left atrium and mitral orifice are used to approach the left ventricular outflow tract and the aortic valve, has proven in our hands to be extremely dangerous because of the likelihood of tearing the septal mitral leaflet. Finally, an approach directly through an incision in the ascending portion of the aorta.

Fig. 9. (a) Supravalvular approach to the aortic valve through the ascending aorta. Strip of pericardium sutured to edges of incision into the aorta and purse string applied to periphery of the pericardial strip. A curved Potts clamp is applied for exclusion of this portion of the aorta. (b) The left index finger advanced through the “pericardial pouch” for exploration of the diseased valve. A smaller second compartment of the pouch prepared for admission of the aortic dilator.
aortic arch was chosen as a most direct one permitting palpation of the valve cusps and orifice, and facilitating accurate and appropriate instrumentation of the valve.

Accordingly, on March 6, 1953, a patient (R. C.) with both aortic stenosis and insufficiency was operated on through a sternum-splitting incision. A portion of the ascending aortic arch was excluded by a curved Potts clamp. A strip of pericardium, two inches by three inches was sutured to the edges of a longitudinal incision made in the excluded aortic tissue, creating a pouch or “aortic appendage” (fig. 9 a and b). A purse-string suture of heavy braided silk was placed about its free extremity. The operator's bare left index finger was inserted into the pouch and, as the clamp was released, it was advanced through the aortic incision into the region of the aortic valve: The valve was palpated, commissural fusion was identified, and the valve opening was located and measured. The olivary tip of the guide wire of the aortic dilator was advanced along the intravascular finger tip until it passed accurately through the valve opening into the left ventricle. The operator's finger was then withdrawn as the aortic incision was clamped and the instrument was inserted into the pouch in its place, finally entering the valve orifice in retrograde fashion to accomplish wide dilatation. The aorta was then reclamped and sutured. Subsequently the technic has been modified so that the pouch is divided into two sections allowing insertion of the finger and instrument at the same time (fig. 10 a and b).

This technic has since been applied with some modification in nine patients. In seven, the sternum-splitting approach was used as described. Then one of us (H. E. B.) suggested the right second intercostal space as less sanguineous and less shocking. This approach has since been utilized twice. Whereas the actual pericardial pouch was used, as described, five more times, it has in two cases been replaced by a rubber-plastic pouch with two finger-like projections. This is sutured to the lips of the aortic incision as described, and then the dilating mechanism of the instrument is entirely enclosed in the longer pouch “finger.” The operator's ungloved left index finger is inserted into the other projection (fig. 11).

After removal of the aortic clamp, the finger explores the aortic valve, guides the wire in retrograde fashion through the diminutive

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**Fig. 10.** (a) The aortic guide wire advanced through the stenotic aortic valve under palpatory guidance with the left index finger. (b) The aortic dilator is advanced through the valve orifice and the triradiate bars are expanded to separate the commissures of the valve.
COMMISSUROTOMY FOR RHEUMATIC AORTIC STENOSIS

FIG. 11. A rubber-plastic pouch may be used to replace the pericardial pouch.

aortic orifice, feels the dilator head as it becomes engaged in the valve, and subsequently evaluates the effectiveness of the commissurotomy accomplished. The aorta is then reclamped, the pouch is removed, and the vascular incision is closed by one row of evert ing mattress sutures, and one running suture of fine arterial silk (fig. 12).

The transaortic operation seems to be well tolerated, seems equally effective, and should be safer than the transventricular one because it avoids ventricular injury. However, two early patients died after several days, apparently because of hemorrhagic extravasation from the split sternal edges. It is certain that the right intercostal incision will avoid this complication. In older patients where the aortic wall may be friable, the transventricular approach should be preferable.

While our present experience has obviously been meager with this transaortic technic, it has already been possible to make certain important observations. For instance, we were amazed to find that the actual remaining valve orifice in two cases was so small as to barely admit the olivary tip of the guide wire (3 to 4 mm. diameter). It is almost unbelievable that life can be maintained with such a severe degree of aortic obstruction. Undoubtedly attempts must be made to treat these patients at an earlier stage.

Again, we were surprised that the amount of surgically produced valvular enlargement was somewhat less than we had expected, even when the dilator head was opened to the fullest extent. While our present dilator head is apparently adequate for aortic commissurotomy in average-sized females, it is evident that a larger head is necessary for maximal improvement in large males. A larger sized dilator head is now in process of manufacture.

The presence or absence of calcification, the presence or absence of commissural fusion, and some idea of the amount of coexisting aortic regurgitation can be readily established by transaortic digital palpation.

SUMMARY

The rheumatic stenotic aortic valve may be approached for surgical commissurotomy either by the transventricular or the transaortic route.

We feel that many young patients with iso-
lated aortic stenotic disease should be operated upon from above.

Probably patients with aortic stenosis and mitral insufficiency should be operated upon from above at the first operative stage. The mitral lesions should be sutured at a subsequent operation from below, if this operation is still considered necessary.

We feel that cases of combined aortic and mitral valve stenosis should continue to be operated upon at one stage from below. The simplicity of the necessary surgery and the low combined operative mortality experienced in this type of patient seem to justify this belief.

We feel that commissurotomy for rheumatic aortic stenosis is a sound, logical, and extremely effective operation. With individualization of the operative approach in the different types of cases, and with greater experience in selection and management, we feel that it bids fair to rank with mitral commissurotomy in safety and in clinical effectiveness.

**SUMARIO ESPAÑOL**

Desde mediados del año 1949 se ha demostrado por el autor “senior” que cualquier mecanismo de dilatación obtusa aplicado dentro del orificio aórtico estenótico, al expandirse separaría una o más de las comisuras fundidas. De esta manera el orificio diminutivo valvular puede ser agrandado sin la creación de una insuficiencia adicional y con la restauración de parte de la función original de la valvula permissible por la distorsión patológica de los pliegues. En otras palabras, los principios y la efectividad de una comisurotomía aórtica serían comparables a aquellos de la operación para estenosis mitral. A descansado en nosotros el desarrollar un instrumento y una técnica capaz de llevar a cabo estos conceptos y esto ha sido finalmente logrado.

**REFERENCES**
