Surgery for Mitral Stenosis
A Review of Progress

By Edward F. Bland, M.D.

The past five years have witnessed a widespread renewal of interest in operations for mitral stenosis. Our surgical colleagues have pushed forward with courage, skill, and notable success, their efforts to relieve the obstructed mitral orifice. It is the purpose of this report to review briefly the background of this revival, to summarize the more recent developments and, with the cooperation of those most concerned, to appraise the results and the risks involved. Our interest is primarily from the point of view of the patient and his physician; surgical technics are not our concern.

Early Contributions

A capitulation of the attempts in the past to break down the barrier of stenotic valves is a fascinating exposition of boldness, persistence, and futility. Until the turn of the century the prevailing views as to the surgical sanctity of the heart were epitomized by the renowned Billroth in 1883: “Let no man who hopes to retain the respect of his medical brethren dare to operate on the human heart.”

However, the advent of asepsis, experimental laboratories, and another century opened new vistas. It was Sir Thomas Lauder Brunton (of amyl nitrite fame) who proposed in 1902 the possibility of surgical intervention for mitral stenosis. Although this precipitated a vigorous and somewhat sarcastic editorial in the next issue of the London Lancet of that year, it served to stimulate further the experimental approach which had already demonstrated in animals the feasibility of such a procedure (Klebs, 1876), and led to the subsequent studies of MacCallum (1906), Cushing and Branch (1908), Bernheim (1909), and Schepelmann (1912).

Thus was the stage set for the first attempt in a human being by Doyen in 1913. Instead of a patient with mitral stenosis, he chose a young woman of 20 with congenital pulmonary stenosis, and he attempted to relieve the obstruction with a tenotome knife passed through the right ventricle. The patient expired a few hours later and necropsy revealed a tubular narrowing of the conus (as is often the case) rather than a localized stenosis of the valve.

A year later Tuffier (1914) exposed the heart of a young man with advanced aortic stenosis. It was his intention to insert a knife above the aortic ring and incise the stenosed valve, but during the operation this plan was abandoned. Instead, dilatation of the stenosed orifice was accomplished by invaginating the wall of the aorta with the forefinger. The patient survived and was reported living and possibly improved 10 years later.

Thereafter another decade elapsed and the extensive experience with cardiac wounds in World War I accrued before further attempts were forthcoming.

In 1923 Cutler and Levine reported the first case of a successful section of the valve for advanced mitral stenosis. The patient, a girl of 11 years, had been observed for eight months at the House of the Good Samaritan (Boston) with recurring episodes of acute dyspnea and hemoptysis, and because of the increasing gravity of her symptoms she was transferred to the Peter Bent Brigham Hospital for surgery. A tenotome knife was passed through the left
ventricle and an attempt made to incise each cusp of the obstructing mitral ring. Although the postoperative state was critical, the patient survived, but the signs of mitral stenosis persisted; the diastolic murmur was slightly altered and there was a prolongation of her systolic murmur. She lived four and a half years after operation, but her activities were seriously limited and she required hospitalization on several occasions for rest and treatment. She finally succumbed with bronchopneumonia and extensive congestion of the lungs.

Necropsy revealed moderate stenosis of the valve, but the orifice admitted a bougie 4 cm. in circumference. The site of the previous incision was easily recognized by a defect in the thickened rolled edge of the valve ring joined towards the base by a thinner membrane-like structure (fig. 1). There seemed no doubt the orifice had been enlarged by the operation. Furthermore, there was no suggestion of an overgrowth of scar tissue in the healing process. This is a key case: it not only represents the first survivor of valve section but the subsequent four and a half years of life also provide an indication of the favorable type of valve healing hoped for in those now being submitted to surgery.

During the next five years (1923–28) Cutler and his associates undertook a somewhat similar procedure in six additional patients: none survived. Allen, also in 1923, attempted to approach the valve through the left atrium with a cardioscope devised by Allen and Graham, but the patient succumbed during the procedure.\^* Souttar (1925) successfully dilated the mitral ring by finger and his patient survived (a forerunner of the present most favored procedure), but Pribram’s attempt (1925) with a valvulotome through the left ventricle ended fatally on the fifth day.

Thus, during the 1920’s 10 patients with mitral stenosis were subjected to valve section or digital dilatation as follows:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutler and associates (section)</td>
<td>7 (1 survived)</td>
</tr>
<tr>
<td>Allen (cardioscope)</td>
<td>1</td>
</tr>
<tr>
<td>Souttar (dilatation)</td>
<td>1 (survived)</td>
</tr>
<tr>
<td>Pribram (section)</td>
<td>1</td>
</tr>
</tbody>
</table>

The 80 per cent mortality was discouraging. However, in spite of this unfavorable experience, interest at the laboratory level continued, and between 1929 and 1932 Powers was successful in producing in dogs gross deformity of the mitral cusps by electrical coagulation followed by infection with intravenous inoculations of Streptococcus viridans. Later healing in those who survived yielded a scarred valve with an element of stenosis. Subsequent valvulotomy led to acute cardiac dilatation and failure in the majority of the animals. From these experiments he concluded that the abrupt creation of mitral regurgitation was a hazardous procedure which in man might likewise lead to acute decompensation and death.

\* It is of interest, particularly for historical accuracy, to note that since the earlier reports of Cutler and Beck, and including the more recent ones of Harken, of Bailey, and of others, reference to this case operated upon in 1923 has been erroneously cited as “Allen, D. S., and Graham, E. A.: J. A. M. A. September 23, 1922,” and “Allen, D. S.: Arch. Surg. January, 1924.”

A careful check of these two references reveals no mention whatsoever of a human case. In view of this discrepancy and the obvious error perpetuated through almost a quarter of a century, and in response to a personal communication from the author, Dr. Evarts A. Graham kindly supplied the correct reference to the original report by Dr. Duff S. Allen.
Clinical support for this deduction was inferred from the remarkable case recorded by Adam (1927) of perforation of the anterior leaflet of the mitral valve by a bullet in a young man of 19 who attempted suicide but survived. He was left with the sign of pure mitral regurgitation—a loud blowing systolic murmur at the cardiac apex. He lived 10 years, but his course was marked by progressive cardiac enlargement, auricular fibrillation, chronic congestive failure, and death. A photograph of this unique specimen is reproduced in figure 2, since, as in Cutler and Levine's case, it gives a clue to the type of healing which occurs following valve trauma (and surgery). Healing around the defect had been accompanied by only minimal thickening of the adjacent valve substance. It is of further interest that as a result of regurgitation all the heart chambers in this case were greatly hypertrophied and dilated.

Thus it is understandable that these combined clinical and laboratory failures temporarily discouraged further attempts at valve surgery until after World War II. In the interim, from a combination of circumstances, there evolved slowly an attitude of renewed confidence where heretofore the dismay of former failures had prevailed. Notable in this connection were the remarkable results obtained in the correction of congenital defects, as well as the favorable experience with cardiac wounds in another world war—this time with the actual removal of missiles from the heart cavities—and finally, there emerged a new generation of dynamic surgeons, fully fortified with catheterization data and hydraulic formulas. The inevitable outcome was a more sustained and successful attack upon the obstructing valve.

Collateral Procedures

Discouraged by the prohibitive mortality of the earlier efforts to relieve mitral stenosis by a direct approach, others sought an indirect solution to the problem.

A special challenge was presented by those patients with high grade stenosis, little or no cardiac enlargement, and recurring (sometimes fatal) attacks of acute pulmonary congestion and hemorrhage. Their disability clearly involves extreme pulmonary hypertension behind an obstructed valve outlet, secondary alterations in the lungs, and a strong right ventricle. Under conditions of stress, tachycardia, and increased blood volume the augmented activity of the hypertrophied right ventricle floods the lungs whose outlet is fixed by the narrowed mitral orifice. Under these circumstances pulmonary edema and hemorrhage are inevitable. It is an acute increment in the already excessive pulmonary pressure which is responsible for this vascular crisis within the lungs (fig. 3). Medical measures (digitalis, diuretics, and diets), although helpful, are ultimately ineffective in dealing with this clinical paradox.

Two clues exist which suggest that help might be available for them outside the heart. In 1926 Jarotzky called attention to the apparent protection afforded the lungs in patients with mitral stenosis who had a congenital atrial septal defect (Lutembacher's syndrome). The protective action of this defect in lessening pulmonary hypertension and congestion has been substantiated by clinical observation, and by catheter studies. Jarotzky suggested that the surgical creation of such a defect might be helpful, as did O'Farrell in 1938. This was actually accomplished by Harken in 1948 but has now been abandoned in favor of the direct operation upon the valve.

Another clue in a different direction is presented by the remarkably dilated bronchial
veins in patients with longstanding mitral stenosis—an attempt by nature to provide an outlet from the congested pulmonary bed into the systemic veins. Thus, in those whose pulmonary syndrome is characterized by massive hemorrhage from these dilated varices (on occasion up to 500 cc.), the accompanying edema is often strikingly relieved or actually aborted. It is unfortunate that this natural protective mechanism sometimes leads to fatal exsanguination.

In 1946, with these facts in mind, Bland and Sweet decided that a vent from the high pressure area of the left atrium or adjacent pulmonary veins into a systemic vein might offer relief to these patients. At that time an extracardiac shunt seemed less risky than either an intracardiac septal defect or a direct operation upon the valve. After two more years of deliberation and study the operation was successfully performed (March 1948) on a 17 year old girl. An anastomosis was effected between a branch of the right inferior pulmonary vein and the azygos vein (fig. 4). A vigorous diversion of blood from the pulmonary circuit into the systemic vein ensued. Direct measurements of left intra-atrial pressure in later cases confirmed the hope that a significant lessening of tension would result.

Subsequent course of this patient was so remarkable, and the animal experiments of Swan were so encouraging, that during the following two years (1948-49) 12 patients with recurring severe pulmonary edema were likewise operated upon, and more recently two additional patients have had this procedure. Certain physiologic data...
assembled at the time of operation are shown in table 1. It is to be noted that the pressure by direct measurement in the left atrium was from four to five times normal in all instances, and upon release of the shunt there usually occurred within a few moments a prompt drop of approximately 80 mm. of saline (unpublished data, Bland and Sweet, 1951).

The later course of this group has been of special interest. Fully half have had striking and continued relief from pulmonary edema, several were much benefited for one to two years but are now beginning to have milder recurrences of their previous trouble (suggesting a possible closure of the shunt), a few had only questionable benefit, and three succumbed within a few days of the procedure.

As was emphasized originally by the authors, this procedure is at best a compromise and not a cure. It was designed only for those with relatively small strong hearts as a protection to the lungs.

In France, d'Allaines and associates, unaware of this earlier work in Boston, performed a somewhat similar procedure (January 1949) and subsequently operated on 16 additional patients with encouraging results in the majority, but they have now shifted to the direct approach (as have Bland and Sweet) as a more promising and less difficult operation.

These purely palliative measures of the past three years have now been overshadowed and quite properly replaced in large measure by the direct attack upon the mitral valve. The remarkable improvement in technic and the consequent lessening of the risk have rendered other methods less attractive and somewhat obsolete, but nevertheless useful, perhaps, under special circumstances where complicating aortic valve disease (regurgitation) already places a strain upon the left ventricle.

**Direct Operations**

Concurrently with the foregoing developments, a more aggressive attack upon the valve itself by several groups has yielded remarkable results, a colorful glossary of terms (valvuloplasty, commissurotomy, finger-fracture, and stenotomy) and, in certain quarters, even a new philosophy which intimates that all patients with mitral stenosis should have their valves split.

In the forefront, and a brilliant exponent of this resurgent interest in valve surgery, was H. G. Smithy, Jr. His untimely death in 1948 at 34 was a tragic loss—he was himself a victim of aortic stenosis. Through the continuing efforts of Harken in Boston, of Bailey in Philadelphia, of Blalock in Baltimore, and of Brock in London, as well as of others elsewhere, enough data have now accumulated to warrant an appraisal of the present status and future promise of the direct approach. I am indebted to these surgeons and in particular to their medical associates* for permitting me to pool their results for the purpose of this report. Minor differences of opinion exist as to technics and indications, but there is wholehearted agreement as to the immediate benefits to be

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* I am especially indebted for personal communications concerning the medical aspects of the operated cases from Drs. E. Cowles and Andrus (Baltimore), Maurice Campbell (London), George C. Griffith (Los Angeles), and Prof. J. Lenègre (Paris).
expected, of respect for the risks involved and of the uncertainties of the future.

In regard to technic, all agree that the approach through the left atrial appendage is safest and surest. Most surgeons prefer digital dilatation, with "finger-fracture" when possible, as less risky than incision in a blind field with a valvulotome. It is clear, however, that each method has a place. In general, calcified valves fracture more readily than heavily scarred and gristly structures. Unfortunately, a few are encountered for which neither method is adaptable. In the author's clinic the follow-

Figure 5 illustrates the most favored procedure, so-called "finger-fracture valvuloplasty" (Harken). It has been emphasized by Harken and his associates, and substantiated by others, that incision in the region of the anterior cusp is followed by far greater regurgitation than is an operation on the posterior cusp (selective insufficiency) or resection of the immobilizing commissure bridges. Bailey and his group prefer incision in the region of the

Figure 5. Diagram of finger-fracture valvuloplasty. The index finger is passed through the left auricular appendage and left auricle to reach the mitral orifice. (Courtesy of Dr. Dwight E. Harken, 1951.)

obiterated commissures which favors (in agreement with Harken) less regurgitation and more effective valve function—so-called "commissurotomy" (Durant), as shown in figure 6. More recently a less descriptive but more inclusive term, "stenotomy," has been suggested for both procedures (Alroy).

An ingenious and different approach has been undertaken by Murray. A cardioscope is passed through the left ventricle, and the mitral valve

Fig. 5. Diagram of finger-fracture valvuloplasty. The index finger is passed through the left auricular appendage and left auricle to reach the mitral orifice. (Courtesy of Dr. Dwight E. Harken, 1951.)

Fig. 6. Diagram of commissurotomy. The right index finger bearing the commissurotomy knife has been inserted through the left auricular appendage and the hooked blade engaged on the lateral commissure. (Glover, Bailey and O'Neill: J. A. M. A. 144: 1049, 1950.)
is resected. In order to compensate for the resulting regurgitation, a sling-like structure composed of a section of vein, everted and supported with a length of tendon, is suspended on the ventricular side of the orifice for a ball-valve action. Of 10 patients, there were eight survivors. It would seem, however, that this procedure is too complicated and too unphysiologic to offer promise.

For the special purpose of this report a survey of the experiences in selected centers in this country and abroad indicates that during the past three years, 352 patients with mitral stenosis have been operated upon, and from collateral reports of operations elsewhere it is quite likely that the total now approaches 500 cases.

### Table 2.—Operations for Mitral Stenosis

<table>
<thead>
<tr>
<th>Author's series</th>
<th>Cases</th>
<th>Mortality</th>
<th>Embolism</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bailey et al.†</td>
<td>135</td>
<td>17 (10.3%)</td>
<td>9 (5.4%)</td>
<td>“majority”</td>
</tr>
<tr>
<td>Harken et al.35</td>
<td>62</td>
<td>17 (27.4%)</td>
<td>4 (6.4%)</td>
<td>“majority”</td>
</tr>
<tr>
<td>Brock et al.13</td>
<td>50</td>
<td>8 (16.0%)</td>
<td>2 (4.0%)</td>
<td>37 (74.0%)</td>
</tr>
<tr>
<td>Blalock et al.14</td>
<td>30</td>
<td>2 (6.6%)</td>
<td>1 (3.3%)</td>
<td>26 (86.9%)</td>
</tr>
<tr>
<td>Longmire et al.44</td>
<td>25</td>
<td>4 (16.0%)</td>
<td>4 (16.0%)</td>
<td>“most”</td>
</tr>
<tr>
<td>Brantigan18 (Baltimore)</td>
<td>12</td>
<td>3 (25.0%)</td>
<td>1 (8.3%)</td>
<td>7 (58.3%)</td>
</tr>
<tr>
<td>Author’s series (Boston)</td>
<td>8</td>
<td>2 (25.0%)</td>
<td>0</td>
<td>6 (75.0%)</td>
</tr>
</tbody>
</table>

| Totals†         | 352   | 53 (15.0%)| 21 (6.0%)|

* As of approximately May 1951. † Operations by Drs. J. G. Scannell and R. H. Warren.

In table 2 are summarized the results furnished the author (mostly as of May 1951) from seven centers. The 352 cases include the early and hence most unfavorable types; thus the mortality figures are weighted in an unfavorable direction. With rapid improvement in technics and a more discriminating selection of patients, there has been a gratifying improvement in the results, so that now a fair estimate indicates a 10 to 15 per cent operative risk for those patients with relatively slight to moderate cardiac enlargement but with advanced mitral stenosis and severe pulmonary hypertension, and a correspondingly greater risk for those with larger and weaker hearts. The further hazard of postoperative embolism, although often nonfatal, remains a distressing aftermath for a few (6 per cent).

An early and dramatic improvement has occurred in the majority of patients. Further clinical observation and catheter studies support the substantial benefits predicted from the early improvement.36, 39

### Selection of Cases

The selection of patients for either of these formidable procedures must of necessity rest largely with the internist and cardiologist. This aspect has been emphasized recently by Harken and co-workers.38 I am indebted to the internists intimately associated with the surgeons listed in table 2 for their opinion and criteria in the selection of patients.

In general it is agreed that the most suitable cases are those with a high degree of mitral stenosis with little or no evident regurgitation, and with unmistakable signs and symptoms of pulmonary engorgement (dyspnea, cough, pulmonary edema, or hemoptysis). The smaller the heart, the better the outlook. Those with large hearts and chronic congestive failure are poor risks and are unlikely to benefit significantly from surgery. Auricular fibrillation or previous embolism increase the hazards slightly but do not constitute contraindications per se. It is unlikely except in special instances that worthwhile benefit can accrue for patients beyond 50 years of age.

There are two absolute contraindications to surgery: active rheumatic carditis and bacterial endocarditis. Measurable strain on the left ventricle from aortic regurgitation (less often stenosis) or from mitral regurgitation renders
operations on the mitral valve doubly dangerous. In special cases where, in spite of these latter complications, the patient’s life is being threatened by recurring pulmonary edema, a pulmonary-azygos shunt may offer a reasonable compromise. We have recently undertaken this successfully as an alternative in a patient with considerable aortic regurgitation.

A further attempt to classify patients into subgroups for assessment for surgery may ultimately prove useful, but at the moment it is somewhat unsatisfactory and controversial. For the present the general principles outlined above seem safest.

The high incidence of Aschoff bodies (up to 25 per cent) noted in biopsies of the atrial appendage has been a surprising finding and out of line with clinical evidence of rheumatic activity. In view of the scant evidence under these circumstances of clinical rheumatic activity and the absence of significant postoperative reactivation, there is need for a further critical review of these clinical-pathologic relationships and perhaps some modification in our present concepts of “activity.”

In concluding this review, it is with awesome admiration that one recounts the remarkable progress of the past five years made by our surgical colleagues. In the face of the dramatic improvement after operation in these often desperately ill patients, the enthusiasm of the moment is understandable, and the desire to extend these possible benefits to those not yet in need of help is tempting, especially since they present to the surgeon more favorable operative risks. In this connection, however, it is timely to emphasize that mitral stenosis is not always a progressive lesion and patients with lesser degrees of deformity may attain a comfortable old age. The long term observations of Bland and Jones on 1000 children followed for 20 years after rheumatic fever reveal the development of mitral stenosis in 117 patients. Of this group during the two decades of follow-up, only 12 have progressed to a state of disabling pulmonary hypertension with acute pulmonary edema and hemorrhage (now mostly in the third decade). Encouraging also in the older age group (from 30 to 40) are the factual data of Grant on the after-history of 1000 soldiers invalided from the British Army after World War I with valvular heart disease. During the 10 year period of observation he found that in those with mitral stenosis:

“The prognosis in cases with signs of early stenosis is good and in them exercise tolerance is best and cardiac enlargement least; about half live uneventfully and unchanged, only a small proportion, about 5 per cent, develop auricular fibrillation and congestive failure, and about 10 per cent die within 10 years. In the presence of great cardiac enlargement and congestive failure the prognosis is bad, very few cases displaying these signs survive the 10 years; the average of life is four to five years.”

Further data on the adult age groups by decades are needed and will soon be available, but for the moment a formidable operation upon the mitral valve had best be reserved for those in need of relief and the benefits to date justify the risk involved. On the contrary, for those with little or no disability the operation seems illogical and ill advised. The possible creation in this group of an uncertain element of regurgitation and the hazards of premature auricular fibrillation and embolism render the procedure unacceptable as a purely preventive measure.

The ultimate solution for the majority of these patients is more subtle than the simple correction of a mechanical defect: their problem involves also a diseased myocardium, and their fate is inexorably linked with the vagaries of their rheumatic state.

**Summary**

The renewed interest in surgery for mitral stenosis is reviewed and the progress of the past five years summarized. The present status of the indirect operation (pulmonary-azygos shunt) is discussed, and the notable advances with the direct attack (finger-fracture valvuloplasty and commissurotomy) have been brought up to date (May 1951) by means of a survey of selected centers here and abroad.

Detailed information is available on 352 patients who have had an operation on the mitral valve. It is quite likely that the total now approaches 500 cases.
The over-all operative mortality has been 15 per cent. Post-operative embolism occurred in 6 per cent. Clinical improvement in the majority has been prompt and striking, and this has been fully supported by catheterization data. An appraisal of the more remote effects must await the passage of time.

Those most likely to benefit are patients under the age of 50 with only slight to moderate cardiac enlargement who are nevertheless seriously limited by pulmonary hypertension and congestion.

A formidable procedure of this magnitude should be reserved for those in trouble; it has no place in the management of patients with little or no disability.

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VASCULAR DISEASE


The circulatory aspects of pulmonary insufficiency were studied by cardiac catheterization in 18 patients with chronic hypertrophic vesicular emphysema. The pressures found in the right side of the heart in cases of emphysema without heart failure were normal. In the presence of right ventricular failure, there was elevation of the ventricular pressure and of the mean intra-auricular pressure, as well as of the peripheral venous pressure. The right heart pressure was found to be lower in the sitting position than in the supine position, in opposition to the views of Sir Thomas Lewis.

Cardiac output in cases of emphysema without failure is also normal. The findings of McMichael and Sharpey-Schafer on cardiac output, the lack of value of digitalization in right heart failure and of the presence of a "hyperkinetic circulation" in patients with emphysema were not confirmed. They believed the fullness of the neck veins to be mechanical, due to a rise in intrapleural pressures from negative values to those approaching zero. The circulation times were normal.

BERNSTEIN

ERRATA

In the article “Blood Lipids and Human Atherosclerosis,” by Dr. John W. Gofman and associates (5: 119, 1952), the following change should be read in table 1: the Mean Serum Cholesterol Level for normal males in the 41-50 year age group should be 260 ± 53.

In the article “Surgery for Mitral Stenosis. A Review of Progress,” by Dr. Edward F. Bland (5: 290, 1952), the following changes should be read in table 2: the footnote “(Operations by Drs. J. G. Scannell and R. Warren” applies to the entry “Author’s series (Boston)” rather than to the “Totals.” Please note that Dr. Warren has no middle initial.