BRITISH MEDICAL JOURNAL

LONDON SATURDAY OCTOBER 22 1955

MITRAL VALVOTOMY: A FOLLOW-UP OF 45 PATIENTS FOR THREE YEARS AND OVER

BY

CHARLES BAKER, M.D., F.R.C.P.

Sir RUSSELL BROCK, M.S., F.R.C.S., F.A.C.S.(Hon.)

AND

MAURICE CAMPBELL, D.M., F.R.C.P.

(From the Cardiac Department and the Thoracic Surgical Unit, Guy's Hospital)

Mitral valvotomy is now an accepted treatment for stenosis of the mitral valve and is practised throughout the world by thoracic surgeons, using the same approach and established technique. As mitral stenosis is a common disease, the operation is a frequent and routine procedure in all large centres, and probably 100 valvotomies are undertaken every week in Great Britain alone. The stimulus of this practical treatment has produced many clinical observations and research investigations of varying approach which have added greatly to knowledge of the local and general effects of mitral disease. Mitral valvotomy has shown that the dominant factor in the widespread and differing manifestations of the disease we have long known as mitral stenosis is, in fact, the stenosis of the mitral valve, although the importance of this factor varies in the individual sufferer.

Detailed observations of the varying clinical picture correlated with the signs and measurements have been checked by observations and measurements of the valve in life and action—a most important advance which is well exemplified by Paul Wood (1954) in his Strickland Goodall Lecture—and this has to some extent simplified and clarified what was before confusing and obscure. It is agreed that a successful operation, which relieves a critical degree of stenosis, relieves or banishes the patient's disability and makes the dynamics of the circulation measurably more normal. How lasting this effect is, how it changes the course or natural history of the disease, how it alters the prognosis of the individual patient, have yet to be learnt. The necessary interval of time to follow enough patients who have had a mitral valvotomy is still much too short, but despite these recognized shortcomings we have some evidence to make some preliminary observations.

Scope and Material of the Present Follow-up

Our first patient was treated by mitral valvotomy on September 16, 1948. In June, 1950, we reported six successful operations and two deaths (Baker, Brock, and Campbell, 1950), and stated that "the results in this small series are good enough to show that valvotomy is a thoroughly practical procedure and can now be justifiably recommended in suitable cases." By January, 1952, Brock had operated on 100 patients at Guy's and Brompton Hospitals, and in May, 1952, with Paul Wood,

we reported these, with a follow up of the first 50 patients (Baker, Brock, Campbell, and Wood, 1952). At the end of 1954 we had 27 patients who were in their fourth year after operation at Guy's, 14 in their fifth year, 3 in their sixth year, and our first patient was in her seventh year: these 45 are reviewed here. Three patients were excluded from the follow-up as they lived abroad and we have insufficient information about them, and we are confident that we have had close and personal contact with the progress and present state of the 45 we are considering. In a minority whose distance from Guy's has made a journey difficult we have had information both from them and from their doctors or physicians, with x-ray and electrocardiographic evidence, and have insisted on seeing them personally only if the evidence was in any way equivocal. All 45 patients had a cardiac catheterization before operation; 29 had this repeated after operation, 5 of them more than once. The short time since operation and the small number of patients limit the significance of the follow-up at this stage, but we think that certain observations can and should be made now. Though a much longer period is needed and will no doubt modify our present conclusions, we are also convinced that the number of patients followed should be no larger than can be individually and thoroughly known as persons as well as patients.

In assessing the clinical state of patients both before and after operation we have used the grades of disability that we defined in detail in 1952 (Baker *et al.*, 1952); in the simplest terms these can be summarized as 0, no disability; 1, slight disability; 2, moderate disability; 3, gross disability; and 4, total incapacity.

The pre-operative state of the 45 patients was: 20 in grade 4, or total incapacity; 24 in grade 3, or gross disability; and 1 patient who was graded before operation as 3, has, with subsequent knowledge of her, been reassessed as 2, or moderate disability. One of the main factors in selection of this group was severity, for in the early days of pioneer surgery only those whose prognosis appeared hopeless were given this chance of improvement; and even later, when the operation had proved itself, we were still selecting severe cases both from necessity and in order to establish the limits of the operation. Heart size alone indicates this, for of the

45 patients 12 had a cardiothoracic ratio of 60 or over, and 5 of over 65, the largest being 70. Eighteen patients were in atrial fibrillation and 27 in normal rhythm at the time of operation. There were 31 women and 14 men, a female preponderance that has continued in our series and in others reported. In presenting the follow-up of these 45 first cases it is important to stress that there was no selection of good operative risks or of those who might be expected to get the maximum improvement from operation; it was often the opposite.

THE FOLLOW-UP

First Three Years

The assessment of the total 45 patients over the first three years is shown in the Chart. We have used a change in grades of disability to classify results as excellent, good, fair, or poor, as shown on the left of the Chart. In the follow-up we have been more critical than the patients in

Follow-up of 45 patients for three years. The large blocks show the total assessment at the end of each year; the small blocks the individual patients; the arrows show those patients who lost ground during the follow-up.

assessing their state, and have not relied entirely on functional ability; thus, the onset of fibrillation or alteration in physical findings such as heart size has reduced a patient a grade even if there has been no decrease in activity or increase in symptoms. We have attempted to allow for the mentality and spirit of the individual patients in making an objective assessment, for while most patients make the best of any improvement in health there are a few who will always complain. In this respect, it should be remembered that our early patients had the spirit, and optimism, of pioneers.

The first assessment was made after one year, when the psychological effect of surviving an operation on the heart had to a large extent disappeared, and every patient had experienced one autumn and winter, which are the proper seasons to assess disability from mitral stenosis, either before or after operation. During that year there was one death—a suicide following a seemingly poor result; six were disappointing—five having a fair result or one grade of improvement only, and one having a poor result with no improvement. The majority, 38 out of 45, were classed as good or excellent results.

During the second year four patients lost ground and two died; three of these six dropped from the good class, and one dropped from the excellent to the good class, so that there were 35 of the 45 with good or excellent results at the end of the second year. In the third year two patients showed further deterioration—one of them dying—and nine more patients lost ground, so that the number left with good or excellent results was 29 out of the 45 at the end of three years.

Thus, of the 45 patients who had survived operation, 4 had died and 12 had lost some of their original improvement and five of these were as incapacitated as before operation. Three of the deaths were in patients who had been assessed from the beginning as poor or fair results and were to be expected. The fourth, however, occurred in a patient (G8) who had been classed as a good result; she had aortic stenosis as well as mitral stenosis, but returned to a full life following mitral valvotomy; at the end of her second year, however, she went into failure with the onset of atrial fibrillation, and died as the result of quinidine therapy (Trounce and Finnegan, 1954, Case 1). The reason for her unexpected deterioration was established at necropsy, which showed that her mitral valve was once more tightly stenosed, but her death was premature. Of the 12 who lost ground, one was assessed as only a fair result at the end of the first year, but the other 11 were all assessed as good or excellent results. The diminishing proportion of patients still remaining in the good or excellent class over the three years is shown in the Chart, for 4 out of 38 lost ground in the second year, and 9 out of 35 in the third year. The numbers of good and excellent results dropped from 38 to 35 to 29 at the end of the first, second, and third years, and if this steady drop continued at the same rate there would be few good results after another five years. The follow-up, however, of a smaller number of patients over a longer period does suggest that the effect of valvotomy is likely to be more permanent.

After Three Years

Nine of the 29 patients with good or excellent results at the end of three years have been followed for a longer period. At the end of the fourth year two had lost ground and two remained as good and five as excellent results. There are three patients completing five years of follow-up; two remain excellent results, while the third is our first patient operated on over six years ago, who deteriorated from an excellent result to a fair result in the third and fourth years, and has remained a fair result in the fifth and sixth years.

The state of the 45 patients who have been followed up through the varying period of three to six years, as judged by their assessment at the end of their first year, is given

TABLE I.—Comparison of Results One Year After Valvotomy With Assessment During and at the End of Follow-up Period

	At End of One Year	During Follow-up			At Present
		Died	Lost Ground	Unchanged	
Dead ..	1	—	—	—	5
Poor ..	1	1	—	—	5
Fair ..	5	2	—	3	8
Good ..	17	1	7	9	12
Excellent ..	21	—	6	15	15

in Table I. It shows that, of seven whose immediate result was disappointing, four died and in three the result remained fair, whereas of the 38 whose immediate result was gratifying only one had died, 13 had lost ground, and in 27 the result remained good or excellent. This shows that, although the preliminary assessment on functional improvement gives an indication of prognosis, the future of the individual patient will vary greatly, and a good result from mitral valvotomy is a relative term which needs continued and critical assessment.

With this object various factors that influence the success of mitral valvotomy and the subsequent course are con-

sidered with relation to the findings and follow-up of the 45 patients. The factors considered are the degree of pulmonary hypertension, the state of the valve before valvotomy, the state of the valve after valvotomy, mitral regurgitation, atrial fibrillation, and rheumatic activity. The degree of disability, heart size, and the presence or absence of fibrillation before operation, although factors that may increase the risk of operation, have not appeared to influence the progress after operation.

In addition a detailed comparison is made between the group of 15 patients who have remained as excellent results throughout the period of follow-up and the group of 14 patients whose original assessment of good or excellent has had to be revised owing to subsequent deterioration.

DETAILED STUDY

Degree of Pulmonary Hypertension

In Table II the degree of success from operation is related to the degree of pulmonary hypertension before operation. The patients are divided into four groups showing moderate,

TABLE II.—Average of Improvement Compared With Pulmonary Pressure

	Mean P.A. Pressure in mm. Hg			
	-30	31-50	51-80	80+
No of patients	7	19	13	6
" " deaths	1	1	0	3
Average degree of improvement in grades	1.0	1.8	2.5	1.2

marked, severe, and extreme pulmonary hypertension, as indicated by mean pulmonary artery pressures at rest. The grades of improvement, from 0 to 4, of each individual at the end of the follow-up period are totalled and divided by the number in each group, to give an average degree of improvement. The number of deaths in each group is shown because three of the five deaths happen to be in the small group of six with extreme hypertension, so that the average grade of improvement is greatly affected; for the other three patients in this small group it is 2.3, which is comparable with the larger group showing severe hypertension. There were reliable readings of "pulmonary capillary" pressures with which to calculate pulmonary resistances in only 21, or less than half the patients. In 13 patients with resistances under 500 dynes/sec./cm.⁻⁵ the average grade of improvement was 1.7 as compared with 2.0 in eight patients with resistances over 500. This trend is comparable to the findings in Table II using mean pulmonary artery pressures, which suggests that the greater the degree of pulmonary hypertension the greater the chance of success from valvotomy. That patients with severe pulmonary hypertension do well and maintain their improvement after valvotomy indicates that the secondary changes in the lesser circulation are not so permanent as was once thought, which is also borne out by the large falls of pressure in post-operative readings in the best results (Table III).

TABLE III.—Mean Pulmonary Artery Pressures in mm. Hg Before and After Valvotomy

Case	Pre-op.	Post-op.	Result*	Case	Pre-op.	Post-op.	Result*
G1	62	32	E	G30	24	20	F
G4	40	27	E	G31	46	23	E
G5	59	27	E	G32	41	20	E
G6	100	55	G	G34	33	15	E
G8	85	24	G	G35	49	31	G
G9	52	35	E	G38	35	20	G
G10	63	30	E	G39	55	30	E
G13	51	22	E	G42	44	30	E
G16	100	81	P	G43	75	30	E
G22	26	16	G	G44	55	30	G
G23	RV 31	RV 6	G	G46	52	20	E
G25	RV 32	RV 46	F	G55	81	35	E
G26	33	25	F	G58	35	18	G
G27	57	36	G	G59	80	30	E
G29	84	23	E				

* Assessment after one year expressed as excellent, good, fair, or poor.

The measurements in three patients, all early in the series, who have had more than one catheterization after operation, are of interest, and are shown in Table IV. The first two were catheterized one year before operation, so that their immediate pre-operative pressures may well have risen further, as they had done in the third; both had

TABLE IV.—Catheterization Data in Three Patients Before and After Valvotomy

Patient Date of Op.	Time	P.A. Pressure in mm. Hg	Rhythm	Cardiac Index (L./sq.m./sec.)	O ₂ Saturation Mixed Venous Blood %
G1 16/9/48	1 yr. pre-op.	60 mean	Sinus	1.9	46
	2 mths. post-op.	32 "	"	2.5	65
	3 yrs. "	40 "	"	2.4	53
	5½ yrs. "	48/29 26 mean 40/18	"	1.9	53
G5 5/9/49	1 yr. pre-op.	59 mean	Sinus	2.3	58
	6 wks. post-op.	50 "	A.F.	1.5	54
	1½ yrs. "	70/30 30 mean 40/18	"	2.0	65
G6 2/3/50	2 yrs. pre-op.	80 mean	Sinus	2.4	60
	1 mth. "	100 "	"	2.7	45
	5 mths. post-op.	130/78 50 mean 68/42	A.F. Reverted with quinidine A.F. in 5th year	2.4	61
	4½ yrs. "	32 mean 40/26	A.F.	1.8	58

in fact deteriorated, the second having fibrillated and been in right-sided failure between the pre-operative catheterization and operation. In the first, G1, a drop in pressure was found shortly after operation, but in the second, G5, who appeared to have an equally good operative result, we were surprised to find no significant fall in pressure six weeks after operation. This patient maintained that he continued to improve until his maximum capacity was reached in one year, and this is confirmed by the pressure eighteen months after valvotomy, when his mean pulmonary pressure was halved, and both cardiac index and O₂ saturation had improved. It is probable also that the third patient, G6, had not reached his lowest pressure when he was catheterized as long as five months after operation, for the pressures were even lower four years later; the drop in cardiac index on this occasion may be significant, as he had not been so well in his fourth winter after operation and was found to be fibrillating and was not on digitalis; he was digitalized, catheterized, and then normal rhythm was restored once more with quinidine.

Both the first and third patients show that the initial drop in pulmonary pressure has been maintained four and a half years after valvotomy. In the second patient the gradual improvement and slow fall of pressure taught us to delay post-operative catheterization for a year after valvotomy in those who had much pulmonary hypertension before. This gradual fall in pressure, indicating a gradual readjustment of the pulmonary circulation following valvotomy, is clearly of great practical importance. Patients with much pulmonary hypertension and high pulmonary resistances are liable to have a difficult post-operative period and should be given a longer convalescence than those whose pressures are merely a reflection of the stenosis of the valve alone. These catheter figures merely illustrate what has been a common clinical observation with a large number of patients.

State of Valve Before Valvotomy

In Table V the patients are divided into four groups according to the maximum diameter of the valve as estimated before valvotomy, and the incidence of calcification and regurgitation is also shown. It will be seen that in 23, or over half, the mitral opening was estimated as 1 cm. in length, though 17 patients had more extreme stenosis, which indicates that there is a critical size below which patients are incapacitated enough to need valvotomy. Only

TABLE V.—Average Improvement Compared With Size of Valve Before Valvotomy

	Maximum Diameter of Valve			
	Less than 5 mm.	0.5 to 1 cm.	1 cm.	Over 1 cm.
No.	10	7	23	5
Calcification present	4	1	7	2
Regurgitation noted	3	1	5	5
Average degree of improvement in grades	1.7	2.6	1.8	0.4

five patients had a valve diameter above this critical level, and all were found to have associated regurgitation, so that their incapacity was clearly not so predominantly due to tight stenosis. By totalling the grades of improvement, from 0 to 4, of the individual patients and by dividing by the number in each group, an average degree of improvement is obtained. This is a crude method, but it indicates that better results are to be expected when the valve is at, or below, the critical size of 1 cm. in diameter. It is of interest, also, that the group of seven who had the best average improvement of 2.6, which is between a "good" and an "excellent" result, had the smallest incidence of calcification and regurgitation, both occurring in the same patient. Table V indicates roughly what would be expected, that patients who are likely to derive most benefit from valvotomy are those with "tight" and uncomplicated stenosis.

State of Valve After Valvotomy

In Table VI the 45 patients are divided into five groups according to the state of the mitral valve after valvotomy. To assess the state of the valve by the length of the aperture is only a rough method, for it is an elaborate functional

TABLE VI.—Final Result in Follow-up, Compared With State of Valve After Mitral Valvotomy

	State of Valve after Valvotomy				
	Poor (Predominant M.I.)	Poor (2 cm. or Less)	Fair (Over 2 cm.)	Good (Over 3 cm.)	Excellent (Full Opening)
Total No.	3	7	17	10	8
Died	2	2	1	—	—
Poor result	1	1	2	1	—
Fair	—	4	4	—	—
Good	—	—	6	2	4
Excellent result	—	—	4	7	4

structure and not a simple diaphragm. From the detailed descriptions of the state of the valves made at operation this measurement, however, is an important and common factor that has the advantage of being expressed in figures.

The patients can, by using this factor alone, be divided fairly clearly into four groups, and the measurements given in Table VI were dictated by this, and not arbitrarily chosen. The detailed descriptions of the operation show why this is so. The group where the final measurement was under 2 cm. had rigid or calcified valves which would neither split along the commissures nor cut easily with a valvotome, and only a slight increase in a still rigid valve was achieved. The group with openings of 2 cm. or more were also difficult, and in few was it possible to get beyond the point of maximum stenosis (Brock, 1952), though the opening had been definitely enlarged and the mitral stenosis relieved. In the group with a final opening of approximately 3 cm. it had been possible to split or divide one of the two commissures, giving a wide opening and valve that was capable of good movement. In the fourth group, with an opening of over 3 cm. it had been possible to open both commissures, giving an opening of normal or nearly normal size and a good functioning valve. Three patients whose valve was so immobile after valvotomy that free regurgitation had resulted, although the stenosis was relieved, form a small and separate group. If the same general terms are used as in the clinical result, the operative results can be classed as poor, fair, good, or excellent, classing the three with regurgitation as poor.

When the patients grouped in this way are graded according to their subsequent course there is a close correlation between the degree of success of the operative result and the ultimate benefit. Of the 10 patients with *poor* operative results four died—two in the second year, one in the third year, and one in the fourth year; two patients were never considered to have improved more than one grade, but maintained their slight improvement; two patients who were thought to have had good results after one year lost all the improvement in the second year; and two deteriorated to fair results in their third year. Of the 17 patients with a *fair* operative result, only 10 had good or excellent results after the period of follow-up; one patient, who had a poor result, committed suicide three months after operation, one patient had a fair result and has maintained that improvement; seven patients, however, who were considered to have good results at the end of the first year lost ground subsequently, two of these returning to their state before operation—one in the third and one in the fourth year. Of 18 patients with *good* or *excellent* operative results, all but one remain in the good or excellent class; one patient was moved from excellent to good owing to the onset of fibrillation, though his capacity was unaltered; one patient, however, lost all her improvement in her third year during pregnancy, when heart failure occurred with the onset of fibrillation.

Early in our experience of valvotomy the two physicians found that when the surgeon was satisfied with what he had been able to do at operation there was little cause for anxiety in the post-operative period, and generally the physicians would be satisfied with the result. The evidence shown in Table VI, and summarized above, shows that time has not only confirmed this early experience but has reinforced the prime importance of what is actually done at operation. We now see that in some instances where early clinical assessment as well as catheter findings after operation have indicated a good result, the reason for later disappointment can be found in the surgeon's description of what he had been able to achieve and the state of the valve after valvotomy. The practical importance of this cannot be overstressed. The statement that mitral valvotomy was done successfully on such a date means little, and gives no indication of the future benefit to the patient, unless the surgeon has made at that time a detailed description of what he has actually done. Without this it will also be impossible to decide whether it is reasonable to attempt a second operation; this was done in three of our patients, and a more complete valvotomy was achieved. In this present study the assessment of the operative result has been made later, and independently, by one of the physicians from the detailed description dictated by the surgeon immediately after the operation.

The diseased mitral valve is a more complex and variable structure than the diseased stomach, and the alteration in its function which the surgeon is able to achieve by operation will vary much more than, for example, after a gastrectomy. Although the surgeon does not see the valve, mitral valvotomy is not a blind operation, and the experienced operator will be able to give a detailed description of the functioning state of the valve before and after operation, which is even more important than pressures taken at the time. Without this, the value of mitral valvotomy in mitral stenosis, and its help to the individual patient with the disease, cannot be assessed.

Mitral Regurgitation

In 14 of the 45 patients some degree of mitral regurgitation was noted by the surgeon before valvotomy (Table VII); in nine it was of mild degree and stenosis greatly predominated; in five it was more obvious, and the functional failure of the valve was due to a combination of stenosis and regurgitation; in no instance was it thought that regurgitation predominated over stenosis.

Regurgitation was found rarely in valves with the smallest openings and more commonly with the larger openings

TABLE VII.—*Incidence of Mitral Incompetence Before and After Valvotomy*

	No.	Died	Poor	Fair	Good or Excellent
Significant regurgitation found before valvotomy	5	2	1	—	2
Insignificant regurgitation found before valvotomy	9	1	1	3	4
Regurgitation produced by valvotomy	6	—	2	1	3
No regurgitation before or after valvotomy	25	2	2	4	17

(Table V). Thus, in the 10 patients whose largest diameter was less than 5 mm., there were three with mild regurgitation and all had calcification of the valve, it being extreme in two of them. In the seven patients with the diameter between 0.5 and 1 cm. there was one with marked regurgitation and gross calcification (G5, Fig. 7 in our original report). In the 23 patients with the diameter of the valve about 1 cm.—almost exactly half of the patients—there were five with regurgitation, and in one with extreme calcification it was considerable. In the five patients with a diameter exceeding 1 cm., all had regurgitation and it was marked in three; one of these had a moderate and one gross calcification.

The association between calcification and regurgitation is close. In 14 patients in whom regurgitation was found at operation calcification was present in nine. In those in whom regurgitation was associated with extreme stenosis it was a constant finding, though the regurgitation was mild in all but one; in those with less severe stenosis it was not a constant finding, and in the one patient whose diameter was 2 cm. it was absent. Of the 31 patients in whom no regurgitation was found at operation, there were only five with calcification, and in only two of these was it severe.

As might be expected, the patients in whom regurgitation was found at operation did not fare as well as those with pure stenosis. Of the five with free regurgitation two died, in the third and fourth year after operation; and one is not improved, though she is still alive four years after operation. The first of these three had the most severe regurgitation with a 2-cm. opening without calcification; her stenosis was certainly relieved, for both commissures were split and she was given a full opening and showed some temporary improvement. The second had the common 1-cm. opening with severe calcification, and neither commissure could be divided; she showed no improvement and steadily deteriorated with signs of stenosis and regurgitation. The third patient with an opening of 1.5 cm. and only slight calcification was operated on while pregnant as she had had two previous attacks of pulmonary oedema; both commissures were opened, giving a valve diameter of 4 cm., but after improvement for a year with a successful delivery she deteriorated with clear signs of mitral incompetence and an increasing left-sided electrocardiogram; in her fourth year after operation, with a child to look after, she is more handicapped than before operation, but without it she might well have succumbed with pulmonary oedema. One patient with significant regurgitation and heavy calcification of the valve had a good result from valvotomy with an opening of 3 cm., and although regurgitation was not relieved the result has remained good for four years. All these patients had clinical evidence of regurgitation before operation, but in the fifth (G5) it was not suspected, and no systolic murmur had been heard; he had tight stenosis with a powerful jet through a heavily calcified valve; a successful valvotomy diminished but did not abolish the regurgitation completely, but he has had no clinical evidence of it since, and after five years is still an excellent result as regards his mitral stenosis, though he is now being treated for hypertension.

Of the nine patients with a minor degree of regurgitation, two had poor operative results; one with very tight stenosis, gross calcification, and extreme pulmonary hypertension had

no functional improvement, and died two years later; one with equally severe stenosis and calcification but with moderate pulmonary hypertension had a fair result and has not deteriorated after nearly four years. The other seven had fair operative results, for in none was it possible to open one commissure completely, and regurgitation was relieved in one only by valvotomy; two patients had fair clinical results, three good results, one an excellent result, and one who had a good result for three years deteriorated to a poor result with fibrillation in her fourth year.

It will be seen, therefore, that mitral valvotomy is less successful in those with regurgitation, as this is more often associated with rigid or calcified valves; when these are found it is more difficult to achieve a full relief of stenosis, and they favour the perpetuation of regurgitation. When mild regurgitation is associated with stenosis the chances of good results and prolonged improvement are less than in those with pure mitral stenosis, but even with moderate regurgitation good results from relief of the stenosis are still possible. When mitral regurgitation is predominant over stenosis, valvotomy is, of course, contraindicated, and there is as yet no successful operative treatment for this condition.

There are five patients whose physical signs after operation suggest that mitral regurgitation was produced by valvotomy, though it was not diagnosed at that time. Three patients all had a good operative result and still have an excellent or good functional result in their fourth year, the clinical evidence indicating mild mitral regurgitation without significant stenosis. In the other two it was not possible to achieve a wide opening and the main diameters were 2.5 cm. only; both were thought to have good results initially despite murmurs indicating stenosis and regurgitation, but both lost ground in the second and third years; one developed atrial fibrillation after operation that could not be reverted; in the other the electrocardiogram became progressively left-sided until she lost her improvement in the third year with the onset of fibrillation.

It is not uncommon to hear soft systolic murmurs after valvotomy, and this is compatible with a good operative and functional result. It would seem important that those with a systolic murmur of grade 3 or louder should be watched for evidence of increasing left ventricular size or electrocardiographic preponderance, for even if their stenosis is relieved and does not recur it is possible that mitral regurgitation may cause deterioration later.

Atrial Fibrillation

The onset of atrial fibrillation is a landmark in the natural history of mitral stenosis, and is often a turning-point where deterioration or failure begins. Heart failure is a frequent result, and, though this is often temporary until controlled by digitalis, few patients are as active as before this change in rhythm. One would therefore expect that those who were still in sinus rhythm before valvotomy was needed would fare better after operation than those who had fibrillation; and that those with fibrillation as the result of valvotomy and returned to sinus rhythm either spontaneously or with quinidine might form an intermediate group. This expectation is not realized in these 45 patients, as is shown in Table VIII. There were 27 patients in sinus rhythm before operation; 14 of these developed fibrillation,

TABLE VIII.—*Comparison of Patients in Sinus Rhythm or Fibrillation*

Rhythm	Total	Maintained Improvement	Lost Ground	Died
Sinus before and after valvotomy	13	6	6 (3)	1 (1)
A.F. post-valvotomy; reverted to sinus	11	6	5 (5)	—
A.F. post-valvotomy; not reverted	3	—	2	1
A.F. before operation (attempted reversion in 3; all failed)	18	14	1	3

The figures in parentheses are the number who changed from sinus rhythm to fibrillation during the follow-up.

but 11 of them were returned to sinus rhythm, so that there were 24 in sinus rhythm after operation. Of these, only 12, or half, maintained the improvement that valvotomy produced; two of these had only fair results and 10 have remained in the good or excellent class; all have remained in normal rhythm, though two have had paroxysmal fibrillation. The three patients who developed fibrillation after operation and did not revert all lost ground. In comparison, of the 18 who were fibrillating before operation 14 have maintained their improvement, 13 of them in the excellent or good class.

This comparison is surprising, for one might expect that the group with fibrillation before operation were in a more advanced stage of mitral stenosis than those who were in normal rhythm, and that therefore they would do less well; certainly they seemed a less promising group, for in only three was reversion with quinidine attempted and in each case it failed. It is, however, the progress of the group in sinus rhythm that has, in contrast, been disappointing. The 13 patients who were in sinus rhythm before and after operation fared no better than the 11 who fibrillated after operation and reverted either spontaneously or with quinidine. Twelve of these 24 patients lost ground, and in nine of these twelve the results were considered good or excellent until they developed fibrillation—two in the second year, four in the third year, and three in the fourth year; only one patient showed evidence of losing ground before fibrillation occurred. In two of these patients no disability was noted with the onset of fibrillation, but they have been considered to have lost one grade of improvement and are now classed as good rather than excellent results; three deteriorated with the onset of fibrillation, one still remaining as a good result and the other two as fair results; three lost all their improvement as the result of fibrillation, one during pregnancy, and are now no better than before operation; one patient died in an attempt to restore sinus rhythm with quinidine.

The onset of atrial fibrillation in these patients in sinus rhythm has been a disturbing feature in this follow-up, for it is cases in this group which have not fulfilled our early expectations. In fact, of the 13 patients with good or excellent results who subsequently lost ground, nine did so because of this. Atrial fibrillation develops in the natural course of mitral stenosis. It is too early to say what the ultimate effect of mitral valvotomy on this natural course will be, but it is a reasonable assumption that a successful operation will put the patient back to an earlier stage of his disease, if this is progressive. Why, therefore, have this small group done less well than those who had already progressed to fibrillation before operation? Any explanation must be tentative, as the numbers are small. We have no evidence that continued rheumatic activity was a factor in the group. The heart size was on the whole smaller—average 53% in those with normal rhythm, compared with 59% in those with fibrillation—and there was no evidence of progressive enlargement occurring before the onset of fibrillation. There was no significant difference in the degree of pulmonary hypertension in the two groups.

One factor that might have an effect is the age of the patients, for it is known that the incidence of atrial fibrillation in mitral stenosis increases with age. The average age of the 18 patients who were in fibrillation before operation was 37, while that of the 27 who were in sinus rhythm was 30. The average age of the 13 who did not develop fibrillation post-operatively was 30, and that of the 11 who reverted either spontaneously or with quinidine was 32. Of the 24 patients who continued in sinus rhythm after valvotomy, the average age of the 15 who have remained in sinus rhythm through the follow-up is 30, while the average age of the nine who developed atrial fibrillation during the follow-up was 32. This does suggest that the age of the patient may be a factor in the onset of fibrillation after operation, and subsequently, and that valvotomy has not played much part in altering the natural history of the disease. Age alone, however, can hardly explain the fact that the group in sinus rhythm did not fare as well as those who were in fibrillation, nor

the very striking and permanent deterioration that resulted in three of the patients when fibrillation occurred.

The factor that may well explain the difference in the two groups is the operative result. Of the nine patients in sinus rhythm with good or excellent results who lost ground with the onset of fibrillation, two had a poor, five had a fair, and only two had a good or excellent operative result as assessed in Table VI. In contrast, of the 13 patients who were fibrillating before operation, who were not reverted, and who maintained their good and excellent results, none had a poor, three had a fair, and ten had a good or excellent operative result. That the operation rather than the rhythm is the decisive factor is also confirmed by the fact that those who maintained good results in sinus rhythm had comparable valvotomies with those who maintained good results in fibrillation, and more successful valvotomies than those who did not remain in sinus rhythm.

It would seem, therefore, that in some of these patients we were too optimistic about the permanence of their improvement because they were still in sinus rhythm. Valvotomy had in effect produced an opening above the critical level enough to rid them of their previous mechanical disability, and to return them to active life; their margin was, however, small, though an adequate flow through the valve was maintained while they were in normal rhythm; with the onset of atrial fibrillation, the loss of the small force of atrial contraction was enough to lessen or eliminate that small margin, and they therefore lost ground or reverted to their pre-operative state. The more active life they were able to lead may have been an additional factor. It is probable that the diminution of their margin of safety is a gradual one, though the effect is revealed by the onset of atrial fibrillation. This was well seen in one patient (G19), who remained without symptoms for three years until she began to get increasing pulmonary congestion when pregnant and the onset of fibrillation produced congestive failure. It is difficult to avoid the conclusion that there is gradual re-stenosis of the valve in these patients, and in the one who died after fibrillation the valve was found to be tightly stenosed.

Rheumatic Activity

The degree and duration of active rheumatic carditis are prime factors in determining the course of rheumatic heart disease and the wide difference in prognosis between patients who die early and those who have a full span of years despite clear evidence of past disease. Although rheumatic activity diminishes with the years, it is not uncommon to find evidence of smouldering activity or of more acute episodes later in life. The finding of Aschoff nodes in a remarkably constant proportion of left auricular biopsies by different observers suggests that active disease may be present even where clinical evidence is lacking. The importance of this possibility in the future of patients who have had mitral valvotomy is obvious, for recurrent episodes of rheumatic endocarditis might cause re-stenosis of the mitral valve or lesions in other valves and impair the power of the myocardium to compensate for them. This factor, even if an important one, might require a longer period and more cases than are included here before it became apparent.

We have diagnosed rheumatic activity in 8 of the 45 patients, in 1 of the 5 who died, in 3 of the 13 who lost ground, and in 4 of the 27 who have maintained their improvement after operation. This number is too small to give any clear indication of the importance of this factor after valvotomy, and it is therefore necessary to refer such evidence as we have to the individual patients.

Two patients were thought to have rheumatic activity following operation. In the first, a man of 33 (G18), post-operative fibrillation was not controlled by digitalis, his pyrexia did not respond to antibiotics, his heart size increased, and right-sided failure developed. After 14 weeks he returned home more disabled than before operation, and committed suicide seven weeks later. The report of the coroner's necropsy gave no adequate information to

decide about rheumatic activity. A difficult post-operative period with congestive failure and pulmonary infarction is not uncommon in cases with much pulmonary hypertension, but in this patient there appeared another factor in his disappointing result, which we suspected, without proof, to be rheumatic activity. Had he not taken his life he might have weathered this period, for the other patient had an equally prolonged and difficult post-operative period. This man, with tricuspid disease and severe pulmonary hypertension (G58) gave clear evidence of pulmonary infarctions after valvotomy, which may well have been the explanation of his long pyrexial course and congestive failure, but at the time we thought that rheumatic activity might be present; he has had no evidence of it since.

There were nine other patients whose post-operative or convalescent period was disturbed by pain, usually left-sided, and pyrexia, often producing a transient failure. This appears to be the same syndrome as that described by Soloff *et al.* (1953) as a reactivation of rheumatic fever. Although at first our suspicions were roused, we do not now consider this fairly common occurrence as evidence of rheumatic activity. It is not confined to operations on patients with rheumatic heart disease, and we regard it as a non-specific reaction of the pericardium. We think, however, that this reaction does not wholly explain the post-operative course in these two men and that a diagnosis of rheumatic activity was justified on the clinical evidence. Patients may also notice recurrent chest pain for some years after mitral valvotomy. It is not associated with general symptoms and signs as in this pericardotomy syndrome, and there is even less reason for regarding it as evidence of rheumatic activity. Most patients look upon it as a minor mechanical effect of a successful operation and mention it only if asked; but it may be a troublesome symptom in those whose ill-health or temperament, or a disappointing operation result, gives them grounds for complaint.

Two women, aged 41 and 42, were suspected of recurrent rheumatic activity during the follow-up period because of episodes of peripheral joint involvement and malaise, though neither had typical rheumatic fever. Both were initially classed as good results; one had a difficult post-operative period with the syndrome already described; both had one probable episode of systemic embolism in the first year. Both returned to a full and active life. The first (G27), who was fibrillating before operation, lost all her improvement in the third winter after operation, with pulmonary congestion and pulmonary infarction. Continued rheumatic activity seemed clear enough here to suggest that re-stenosis of the valve had occurred, and this indeed was found when a second and more successful valvotomy was done at the end of four years. The second (G22) was in sinus rhythm, and her heart size had diminished after operation; despite the suspicion of rheumatic activity, she was very active, without symptoms or physical signs of stenosis, until the fourth year, when she suddenly lost all her improvement with the onset of fibrillation, and is now kept from right-sided failure only by medical treatment. Re-stenosis of her valve is possible, for neither commissure was split satisfactorily at operation, but the clinical evidence did not support this, and one is therefore inclined to suspect rheumatic myocarditis as a possible cause for her sudden deterioration.

The third patient (G1), aged 24, who in the four years following operation has shown some deterioration that we attribute to rheumatic activity, was the first patient operated on over six years ago. She had a good result until the third and fourth years, when she lost ground, and the result is now only fair. She has remained in sinus rhythm, and cardiac catheterization in her sixth year is substantially the same as after operation and better than before it; her valvotomy result, the physical signs, and electrocardiogram after operation were no more than satisfactory (Table IX), so it is possible that re-stenosis has occurred.*

*At a second operation, after completion of this paper, re-stenosis was found, but unfortunately she died the day after.

During her period of deterioration she has developed increasing signs of aortic disease, whereas previously these were minimal, and in her sixth year her heart size has increased. This evidence of progressive rheumatic heart disease, which may include re-stenosis of the mitral valve, suggests that rheumatic activity is present. Although embolism is rare after mitral valvotomy, this patient, like the two reported above, had a transient right hemiplegia in her fifth year.

In three other patients there was evidence of rheumatic activity in the follow-up years, but no sign that this has affected the result of operation. One of these had two frank attacks of rheumatic fever in her first year, but she has an excellent result, with no loss of ground in her fourth year after operation (G56).

The finding of Aschoff bodies in auricular appendages removed at mitral valvotomy has raised the question not only of the presence of rheumatic activity in the absence of clinical evidence but also the significance of these findings as an indication of rheumatic activity. The biopsies in our cases were reported on by Dr. J. B. Enticknap (1953) with his findings and conclusions in a larger series with necropsy controls; he is guarded concerning the significance of these findings, and has graded them as "probable" and "possible" evidence of rheumatic activity. In 37 of these 45 patients the auricular appendage was examined, 9 with "probable," 8 with "possible," and 20 with no suggestive evidence of any kind. There is no correlation between these findings and clinical evidence of rheumatic activity before or after valvotomy and the subsequent course in the follow-up years. Of the eight patients in whom rheumatic activity has been diagnosed on the evidence quoted above, it so happens that four were among the eight whose auricles were not examined; in only one of the other four was a "possible" lesion found, while the remaining three, including the patient with two attacks of rheumatic fever in the year following examination, had negative biopsies.

Comparison Between Those Who Maintained Improvement and Those Who Lost Ground

In order to establish criteria for a stricter assessment after operation a comparison was made between the 15 patients who maintained a good or excellent result for three years or more, and the 14 who were classed as having excellent or good results after one year, but who subsequently lost ground.

The second column of Table IX shows the number of years that a successful result has been maintained or the year when any deterioration was noted, with the degree of deterioration in brackets—that is, 2-D indicates death from a good result; 3-2 a change from excellent to good result. It will be seen that 5 of the 15 patients have maintained excellent results for more than the three-year period, and that 11 of the 14 who lost ground did so in the third year or later. This emphasizes the need for a long period of follow-up before it is possible to be confident about the success of valvotomy.

The third column is an assessment of the state of the valve after operation as previously shown in Table VI, the figure 1 corresponding to the valve where it was impossible to obtain a full split of both commissures leaving a maximum diameter of 2 cm. or less, and 4 corresponding to a full-size opening with both commissures opened. The fourth column is an assessment of the physical signs on clinical examination after operation, taking into account not only signs of mitral stenosis and regurgitation but involvement of aortic or tricuspid valves and clinical evidence of pulmonary hypertension; details of this complicated assessment would be tedious, but 4 indicates that evidence of any involvement of the mitral valve is difficult or impossible to find, whereas 1 would indicate not only clear evidence of mitral disease but rheumatic heart disease in its widest aspects. The assessment of the electrocardiographic evidence in column 5 is based primarily on evidence of right ventricular hypertrophy or atrial strain as shown in

TABLE IX.—*Comparison Between Patients Maintaining and Losing Improvement After Valvotomy*

Excellent Results Maintaining Improvement					
No. of Patient	Years of Follow-up	Valvotomy Result	Physical Signs	Electro-cardiogram	Heart Size (c.t.r.)
G4	5	3	2	3	63
G5	5	3	3	3	64
G10	4	2	3	3	59-56-60
G13	4	2	3	4	52-48
G21	4	3	3	4	54
G32	3	4	3	3	52
G34	3	3	2	3	68-70
G37	3	2	3	3	56
G39	3	4	2	2	70-62
G42	3	3	2	3	60-52
G43	3	3	4	2	61-56
G46	3	4	4	4	53
G55	3	4	3	3	55-47
G56	3	3	2	3	64
G58	3	2	3	3	67-62
Average	—	3.0	2.8	3.0	—

Excellent and Good Results Losing Ground					
No. of Patient	Deterioration of Grade (and Year)	Valvotomy Result	Physical Signs	Electro-cardiogram	Heart Size (c.t.r.)
G1	3-1 (3)	2	1	1	56-60 (6th year)
G8	2-D (2)	1	2	* 2	58
G9	3-2 (3)	2	2	3	48-52
G19	3-0 (3)	3	2	2	57-55-61
G20	2-0 (3)	2	1	2	57-54-62
G22	2-0 (4)	2	4	3	63-59-63
G24	3-1 (3)	2	2	2	48-49
G27	2-0 (3)	1	1	2	49-50-58
G31	3-2 (3)	4	2	3	53
G38	2-1 (3)	2	2	3	52-53
G40	2-0 (2)	1	1	1	56-60
G47	2-1 (2)	2	2	2	58
G50	3-2 (3)	2	2	3	53
G52	2-1 (3)	2	2	2	56-64
Average	—	2.0	1.9	2.4	—

the P waves, the presence of atrial fibrillation or any indication of left ventricular hypertrophy lowering the patient one grade; thus 4 indicates a normal electrocardiogram in sinus rhythm with no evidence of mitral P waves, and 1 indicates evidence of right and left ventricular hypertrophy, and atrial fibrillation. The sixth column gives the cardiothoracic ratios, with any changes that have occurred in the follow-up, but does not indicate the diminution in size of pulmonary arteries and hilar markings, which were often seen where no overall diminution of heart size had occurred. The presence of organic disease of aortic or tricuspid valves, if significant, will affect the physical signs, electrocardiogram, and heart size.

In comparing the two groups it will be seen that those with maintained improvement had a better average for each individual assessment of operative result, physical signs, electrocardiogram, and change in heart size than those who lost ground. There is no emphatic difference in any one of the criteria, but the summation of all four points shows an overall difference in the two groups. Considering the advanced state of the patients who were operated on, one would not expect to find that a full opening could be achieved in each case with a resultant absence of clinical signs, a normal electrocardiogram, and a diminution of heart size. Nevertheless, one should be more hopeful for a more permanent result in those who show these more favourable points. Thus, in the first group, it would seem reasonable to expect a good future for patients 21, 32, 46, and 55, with a very successful valvotomy, with a minimum of physical signs after operation, and with small hearts. Patients 10 and 13, however, have equally good clinical evidence, but the valvotomy did not achieve a wide opening, and one is therefore more guarded about the future, though there is full functional activity after four years from grade 3, or severe incapacity, before operation. In contrast, patients 34 and 39 both have more obvious clinical signs, and large hearts from tricuspid disease, which may influence their future progress, though it appears that they have been

successfully relieved of their mitral stenosis, with an improvement from total incapacity (grade 4) to slight disability (grade 1).

Patients who need mitral valvotomy differ so much in their clinical state before operation that one would not expect uniformity of findings in cases with equally successful results. Nevertheless, careful and continued assessment of all available data after operation is clearly important in judging the result and its possible permanence.

The importance of this is seen in the second group, who all had good functional results but lost ground later. It will be seen that, with two exceptions, a very successful valvotomy was not achieved, that only one patient was completely relieved of physical signs, that a normal electrocardiogram was never obtained, and that there was a temporary decrease in heart size in only three. The post-operative physical findings are not as satisfactory as in the first group, and in patient 22 only did they compare with the improvements seen frequently in the first group; this patient had evidence of rheumatic activity, but this did not produce functional deterioration or a return of signs of mitral stenosis until she developed fibrillation in her fourth year; it is difficult, however, to avoid the conclusion that some re-stenosis has occurred, since the valvotomy was only moderately successful. Patient 27, who also had evidence of rheumatic activity, had actually re-stenosed; for this was found at a second operation, when a more satisfactory opening was achieved. This patient, like the others in the group, had obvious physical signs despite a good functional improvement, and it would seem that when these are present future deterioration is always a possibility unless a full opening of the valve has been achieved. The only patient in the second group who had a full opening was patient 31, but he was considered to have lost one grade of improvement owing to the onset of fibrillation, though he continued at full employment without digitalis or symptoms.

While detailing these contrasting post-operative findings in this small group, it is pertinent to give our impressions of the larger group who have not yet been followed up for so long a period. We are most optimistic about those we know have been given a wide and functioning valve by valvotomy. This optimism is fortified if there is an appreciable change in the physical signs towards normality. In those in whom the valvotomy is less complete we are less optimistic, even if the physical signs are improved, and are guarded in our prognosis if obvious physical signs remain, however dramatic the functional improvement may seem.

SUMMARY AND CONCLUSIONS

We are reporting the present condition of the first 45 patients who survived mitral valvotomy, all of whom have been followed for three years and some for up to six years. A year after operation there were 38 good or excellent results and only 7 that were disappointing. At the end of three years another 11 of the 38 had joined the disappointing group, leaving 27 good or excellent results. The third year after operation is evidently more critical than the first two years, but some patients who have been followed for four and five years have maintained their improvement and are leading active lives.

If we may add a less complete and more recent follow-up, we have 50 patients who obtained a good or excellent result and have been followed for three years or more. The results after three years are much better in those who were graded as excellent than in those who were graded as good some months after operation, showing that this clinical judgment was in general a valid one for the future. If, however, to make it easier to follow, we combine the good and excellent results, we can say that 38 (76%) of the 50 patients are still as good after three years and 12 have lost ground. Of these

12, 8 (16%) have lost much of their improvement and 4 (8%) have lost all of it, and 2 of these 4 have died.

A smaller number, 19 of the 50 patients, have been followed till the end of the fourth year, and again there was some loss of ground, though 15 out of the 19 have maintained their improvement. Two, however, have lost much of their improvement and two have lost all of it.

We have tried to analyse the influence of various factors on the lasting good results. Rather to our surprise, the size of the heart, the degree of disability, and the presence of auricular fibrillation before operation do not seem to influence the result in this three-year period, though they will no doubt do so in the long run, and fibrillation does increase the operative risk. Obviously, operation should be most successful when the mechanical defect is severe and the heart muscle relatively good, and measurement of the valve at operation shows that the results were better where it was less than 1 cm. in diameter.

The best correlation between a lasting good result and anything that we could assess at the time is with the surgeon's account of what he was able to achieve at the operation. Where he found it impossible to produce an opening that was as much as 2 cm. or where there was gross incompetence, there were no good results; where he was able to produce a full opening or one over 3 cm. there were 17 good results and only one that was poor; and where the valve size was intermediate, 2 to 3 cm., the results were intermediate.

Mitral regurgitation before valvotomy does not always prevent a good result, but even a slight degree of this reduced the proportion of good results and increased those where they were only fair. We thought that regurgitation was produced by valvotomy in 6 of the 45 cases, and in 3 of these the result was poor or only fair, but in 3 it seems unimportant so far. There was a close association between calcification of the valve and regurgitation.

Pulmonary hypertension is a reason for operation rather than a contraindication. We have not met an example where a successful valvotomy has failed to reduce it, and, in general, the greater the degree of pulmonary hypertension, the better the chance of a good result.

The occurrence of atrial fibrillation after operation is perhaps the most disappointing feature. Temporary fibrillation after operation when sinus rhythm is restored spontaneously or with quinidine does not seem to influence the outlook, and these patients behaved in the same way as those who kept normal rhythm all the time. Paroxysmal fibrillation is not uncommon after any thoracotomy, and in some cases it may be of this type. In three patients fibrillation occurred after operation and normal rhythm could not be restored: all these three have done badly, but the numbers are small and we have seen other examples where this is not true.

We are surprised that those who had fibrillation before operation have actually done better in maintaining the improvement gained by valvotomy than those who had normal rhythm before, for 14 of the 18 have maintained good or excellent results. The onset of atrial fibrillation is to some extent a test of the heart's capacity, and unless the heart was able to stand this reasonably well, thus showing some reserve capacity, we may have regarded a patient as too ill to be suitable for operation; also loss of improvement from operation when atrial

fibrillation occurs later indicates that the margin of benefit conferred was not great, and suggests that the valve has re-stenosed.

The prognosis in a young patient depends mainly on whether he receives further cardiac damage by further rheumatic infection. This is less true in older patients, but still has some relevance. We have little evidence, so far, that this is so in our patients. There is no correlation between the presence or absence of Aschoff bodies in the auricle and the clinical evidence of rheumatic activity and the subsequent course of the patients. But there is evidence in three patients, of whom one died and two had second operations, that there was some re-stenosis of the valve, which was more likely due to further rheumatic infection than to fibrosis from stress.

The so-called post-commissurotomy syndrome is, in our view, badly named, and is not specific to these cases. It should be called the pericardotomy syndrome, for it occurs after the pericardium has been opened for pulmonary valvotomy or other procedures as well as for mitral valvotomy.

We have compared in some detail the patients who have maintained their good results with those who have lost them. This difference correlates best with the surgeon's assessment about how much he was able to do with the valve at operation. Although at first the patient's symptoms and increased capacity are more important than any diminution in the physical signs, the latter give a better indication that the good result is likely to be lasting, and improvement in the electrocardiogram or radiograph is also of value.

If, finally, to summarize the prospects of a good result lasting, we may count two patients losing much of their improvement the same as one losing all of it, and even out irregularities, we can say that 2% of our patients lost all their improvement in the first year, 6% in the second year, 10% in the third year, and perhaps 15% in the fourth year. Although this shows progressive deterioration as the years pass, it is better than a preliminary estimate made a year ago, and may become better as more patients are followed. But it is unlikely that improved selection and improved surgery will ever prevent some progressive deterioration, for the operation—unlike that for a persistent ductus—is dealing with a heart that has been damaged by rheumatic infection.

It is pertinent to stress that this is a follow-up of our first 45 patients. These early patients were selected because of their bad prognosis, and some were operated on before the technique of mitral valvotomy was perfected. That all the patients have not maintained their initial improvement is not surprising, but even these have had the benefit of increased or normal activity for a year or more. That second operations can be done on some patients if re-stenosis occurs emphasizes the need for a careful and thorough follow-up.

We are grateful for the co-operation of many colleagues in this work, but particularly to Dr. H. E. Holling and Dr. A. Venner for their catheter studies; and to Miss N. Stapleford for her most valuable secretarial help.

REFERENCES

- Baker, C., Brock, R. C., and Campbell, M. (1950). *British Medical Journal*, 1, 1283.
 ——— and Wood, P. (1952). *Ibid.*, 1, 1043.
 Brock, R. C. (1952). *Brit. Heart J.*, 14, 489.
 Enticknap, J. B. (1953). *Ibid.*, 15, 37.
 Soloff, L. A., Zatuchni, J., Janton, O. H., O'Neill, T. J. E., and Glover, R. P. (1953). *Circulation*, 8, 481.
 Wood, P. (1954). *British Medical Journal*, 1, 1051, 1113.