The natural history of rheumatic aortic regurgitation and the indications for surgery¹

H. J. Smith, J. M. Neutze, A. H. G. Roche, T. M. Agnew, and B. G. Barratt-Boyes

From the Cardiology and Cardiothoracic Surgery Departments, Green Lane Hospital, Auckland, New Zealand

A detailed review was made of 180 patients with severe aortic regurgitation of rheumatic origin. Of these patients, 110 underwent aortic valve replacement. Thirty-nine clinical and haemodynamic factors were studied in an attempt to define those associated with (1) death before surgery, (2) a higher incidence of complications and hospital mortality after surgery, and (3) an unsatisfactory longer-term result after surgery. Only heart failure, radiographic heart size, left ventricular hypertrophy, and ventricular premature beats were associated with death before surgery. No factor predisposed to surgical complications and only pre-operative factors associated with an unfavourable result after surgery were advanced heart failure, cardiomyopathy, extreme cardiomegaly, and ventricular premature beats.

It is concluded that the indications for operation are: a cardiothoracic ratio of greater than 0.60, or a history of heart failure combined with electrocardiographic evidence of extreme left ventricular hypertrophy. Operation may be safely postponed if these indications are not met, though the presence of ventricular extrasystoles or evidence of independent myocardial disease are further factors which should influence the decision.

New Zealand has a relatively isolated community and a high incidence of rheumatic fever, especially among its Maori and Pacific Island people (New Zealand Department of Statistics, 1974) and provides favourable conditions for a study of the natural history of rheumatic heart disease. This fact, together with uncertainty about the indications for surgery in patients with well-compensated aortic regurgitation, prompted us to reinvestigate the indications for surgical intervention in this disease.

Valve surgery is indicated when the risk of operation is less than the risk of postponement. The latter risk includes:

- 1) death without operation
- 2) progression to the point where the risk of operation is excessive, and
- 3) progression to the point where the long-term result will be unsatisfactory despite good surgery.

In the present study, we have examined these factors in an effort to define more clearly the place of aortic valve replacement in the treatment of severe aortic regurgitation.

Received 21 July 1975

¹Supported in part by the National Heart Foundation of New Zealand

Subjects and methods

One hundred and eighty patients with severe aortic regurgitation of rheumatic origin referred to Green Lane Hospital from 1958 to 1967 were assessed. A history of rheumatic fever was definite in 145 patients and probable in the remaining 35 patients. The diagnosis of aortic regurgitation was obvious clinically and there was rarely any doubt about severity though this was difficult to define in quantitative terms (Judge and Kennedy, 1970). In 167 patients, the diastolic pressure was less than 60 mmHg (8.0 kPa), with a pulse pressure greater than 50 per cent of the systolic pressure. A further 13 patients were included with a diastolic pressure greater than 60 mmHg (8.0 kPa), where the findings were consistent with severe aortic regurgitation, usually with heart failure. Data from catheterization were available in 13 patients, but added little to the clinical assessment. The series does not include any patients with associated mitral or tricuspid disease unless the lesion was mild. Fifty-three patients with moderate aortic regurgitation, of non-rheumatic aetiology referred during the same period were also excluded from the study. A review was made of all available past records from medical practitioners and hospitals, including chest radiographs and electrocardiograms. Further information was obtained from patients and relatives. The information collected was recorded on punch cards and analysis was restricted to data recorded with confidence. The influence of the 39 preoperative factors listed in Table 1 was examined

TABLE 1 Preoperative factors examined

1-3	Age, sex, and race
4	Period of observation
5	Time since last review
6	Bacterial endocarditis
7	Age at the first attack of rheumatic fever
8	Number of attacks of rheumatic fever
9	Time interval from first attack of rheumatic fever to onset of symptoms
10	Time interval from first attack of rheumatic fever to assessment
11	Mode of onset of aortic regurgitation (acute or chronic)
12	Duration of significant aortic regurgitation
13	Presence of a mild mitral valve lesion
14	Presence of mild aortic stenosis
15	Presence of cardiomyopathy
16	Presence of systemic hypertension
17	Presence of coronary heart disease
18-20	Angina at rest or on effort or both
21	Duration of dyspnoea
22-24	An episode of paroxysmal nocturnal dyspnoea, orthopnoea, or frank congestive heart failure
25-26	Treatment with digitalis or diuretics
27-29	Systolic, diastolic, and pulse pressure
30-32	Initial, final, and increase in CTR
	<i>Electrocardiographic abnormalities:</i>
33	i Rhythm disturbances
34	ii Frontal plane axis
34	iii Infarct pattern
35	iv Fascicular block
36-37	v Bundle-branch block (left and right)
38-39	vi Degree and duration of left ventricular hypertrophy

in relation to outcome. If a relation between a factor and survival or clinical status became evident, the significance was tested by analysing the difference between two binomial proportions (Goldstein, 1964).

Of the 180 patients studied 22 died, 48 remained under observation throughout the review period, and 110 were subjected to aortic valve replacement. The mean follow-up period for each group was 2.3 years, 3.7 years, and 2.3 years, respectively. It is obvious that the operated patients differed from the other groups in that they had survived to the point where their disease was considered severe enough to warrant valve surgery. In order to obtain an overall view of the way in which the 39 factors studied influenced patient survival it was necessary to consider the 180 patients as a composite group.

A. Factors contributing to death before operation

For this part of the study comparisons were drawn between patients who died before operation, and those who survived either to operation, or without the need for surgery. The time of assessment was taken as the last clinic attendance before death for those who died. Patients submitted for operation were assessed immediately beforehand (the period of observation for this part of the study thus ending at this point), while others were assessed after their last clinic attendance.

B. Factors associated with a higher incidence of surgical complications in patients who came to operation

All 110 operated patients underwent aortic homograft valve replacement (Barratt-Boyes, 1965). Surgical complications were defined as significant residual aortic regurgitation, myocardial damage, conduction defect, or any combination of these following operation. The incidence of each of the 39 factors studied was recorded in patients who suffered surgical complications and compared with the incidence in those who had an uneventful operation. The surgical complication rate does not reflect current results as the study concerns the early period of homograft replacement from 1962 to 1968.

C. Preoperative factors associated with unsatisfactory longer-term result after good operation

Surviving patients were assessed at an average of 2.7 years after operation, the minimum follow-up period being 1 year and the maximum period 4 years. The longer-term result was classified as good if patients were in NYHA (1964) Class I or II with reduction of the radiographic cardiothoracic ratio (CTR) to less than 0.55. The result was classed as satisfactory if patients were in Class I or II, with a reduction in radiographic heart size but with a CTR of greater than 0.55. Other surviving were classed as poor. Late deaths were defined as those occurring after discharge from hospital.

The incidence of each of the 39 preoperative factors was compared in each group—good, satisfactory, poor, late death—in the 76 patients who had entirely satisfactory operations. Exclusion of patients in whom a surgical complication occurred was necessary to permit patients proper assessment of the influence of preoperative factors.

Results

A. Factors contributing to death before operation

One hundred and ten were followed until surgery, 22 died without operation, and 48 were still being managed conservatively at the time of assessment. The incidence of each factor studied was compared in the group of 22 patients who died, with the incidence in the 158 who survived to the time of assessment.

The symptomatic class of the 158 patients alive at the time of assessment (New York Heart Association, 1964) was as follows: Class I—42, Class II—60, Class III or IV—56.

There were only 4 factors from among the 39 studied which were related to the death of patients while under observation. These were heart failure, the size of the heart, the presence of extreme left ventricular hypertrophy, and cardiac arrhythmias (Fig. 1).

FIG. 1 The effects of heart failure (HF), cardiothoracic ratio greater than 0.60 (CTR 0.60+), extreme left ventricular hypertrophy (ExLVH), and arrhythmias (Arrhy) on the death rate without surgical intervention. The histograms show the death rate in the groups of patients with and without each factor. The numbers shown are the total number of patients in each group.

1. Heart failure For the purpose of this study a patient was said to have heart failure if at any time he had an episode of paroxysmal dyspnoea (51 patients), or orthopnoea (62 patients), or congestive heart failure (30 patients). Most patients with heart failure responded to medical treatment and there was no statistical difference in the death rate of patients in these three categories during the period of observation. The categories were, therefore, grouped together, a total of 68 patients being involved. (As noted below, however, the presence of severe congestive heart failure at the time of operation was related to an unfavourable outcome in individual cases.)

This history of an episode of heart failure was related to an increased death rate. Fourteen of 68 (21%) patients with heart failure died, compared with 8 of 112 patients (7%) without heart failure ($0.001 < P < 0.01$; Fig. 1), but most of these 14 patients also showed other unfavourable features. There were no deaths in 13 patients with heart failure but without cardiac enlargement (CTR > 0.60), extreme left ventricular hypertrophy, or arrhythmia.

2. Heart size This was assessed radiologically by the cardiothoracic ratio (CTR) defined as the ratio of heart and internal chest diameter on a 6-foot posteroanterior chest x-ray. Patients who had only anteroposterior x-rays were not included. Eighteen of 78 patients (23%) with a CTR greater than 0.60 died, compared with 3 of 89 patients (3%) with a CTR less than 0.60 ($0.001 < P < 0.01$; Fig. 1). Of these latter 3, one died 3 years after being seen and no details of the death are known,

TABLE 2 Criteria of left ventricular hypertrophy

Voltage	T wave in chest leads		
	S V1 or S V2	+ R V5 or R V6	
Mild	35	—	60 mm
Moderate	i: >	60 mm	Normal
or	ii: —	35–60 mm	Reduced/flat/biphasic
Severe	—	—	0–2.9 mm (inversion)
Extreme	—	—	3 mm < (inversion)

but he may have had an enlarged heart at the time of death. The second patient who had a CTR of 0.50, with first degree heart block and ventricular premature beats, died 8 months after being seen. At necropsy, his heart was enlarged (weight 832 g), with gross hypertrophy of the left ventricle. A third patient had a CTR of 0.59 with extreme left ventricular hypertrophy and ventricular premature beats. There were, therefore, unusual features about each of these 3 patients and 'unexpected death' was exceptional in patients with a CTR of less than 0.60.

Twenty-three patients had a CTR more than 0.60 without heart failure, extreme left ventricular hypertrophy, or arrhythmia and 2 of these patients died.

3. Left ventricular hypertrophy An arbitrary assessment of left ventricular hypertrophy was used, based on voltage and T wave changes as set out in Table 2. Modification was necessary in patients taking digitalis, usually by subtracting 1 grade unless the diagnosis of extreme left ventricular hypertrophy was obvious.

No patient with mild or absent left ventricular hypertrophy died, 9 of 110 patients (8%) with moderate or severe left ventricular hypertrophy died compared with 12 of 47 patients (26%) with extreme left ventricular hypertrophy ($0.001 < P < 0.01$; Fig. 1). However, 6 of the 12 patients had the other 3 factors as well, 4 had heart failure plus a second factor and 2 had one other factor. No patient dying had extreme left ventricular hypertrophy only. Similar considerations applied to patients with severe or moderate left ventricular hypertrophy and it appeared that this affected death rate only in the presence of other factors.

4. Arrhythmias These were recorded in 60 patients (Table 3) and included first degree heart block (24), ventricular premature beats (22), first degree heart block plus ventricular premature beats (7), atrial fibrillation (6), and atrial fibrillation plus ventricular premature beats (1).

Thirteen of the 60 patients (22%) with arrhythmias died compared with 9 of 120 patients (8%) in sinus rhythm ($0.001 < P < 0.01$; Fig. 1). This difference was mainly because of the presence of ventricular premature beats. An arrhythmia was the least important of the 4 factors studied but became significant when other factors were also present. Thus, only 2 of 10 patients with heart failure, an enlarged heart, extreme left ventricular hypertrophy, and sinus rhythm died, while 6 of 12 patients with those 3 factors plus ventricular premature beats died. (It is possible, however, that an unrecorded rhythm abnormality was the immediate cause of death in 6 patients dying without heart failure.)

Other factors studied

Seventy-five per cent of patients were male, but men and women tolerated the disease equally. Thirty-one per cent were of Polynesian descent compared with 6 per cent in a parallel study of patients with aortic regurgitation of non-rheumatic origin. Contrary to the experience in patients with multiple valve disease, all races tolerated the disease equally.

Eighty per cent of patients had had their first attack of rheumatic fever between the ages of 5 and 15 years. The influence of time since the first attack could not be separated from the effect of age and neither was related to death rate. Multiple attacks of rheumatic fever had no discernible effect on outcome, but it is likely that many patients with multiple attacks developed multiple lesions and were, therefore, excluded from the study.

It was not possible to extract reliable information about the duration of severe aortic regurgitation but the duration of significant regurgitation was known in 113 patients, it being considered significant when it produced obvious haemodynamic effects. Unexpectedly, outcome did not relate to this.

Bacterial endocarditis had occurred in 31 patients. This complication led to surgery in 26 cases, but with

the infection fully treated there was no other difference between these patients and those who had not had bacterial endocarditis. Fifteen patients were regarded as having an acute onset or acute deterioration of aortic regurgitation not caused by bacterial endocarditis. There was no difference in the subsequent behaviour of this group compared with that of patients with a more gradual onset.

The death rate of patients with angina at rest or on effort (6/39) was not significantly different from the death rate in patients without angina (16/141). Coronary heart disease was diagnosed clinically in 8 patients, but the numbers were insufficient for analysis. Coronary arteriograms were not performed in the assessment of patients with aortic regurgitation during the period of this study. Neither left axis deviation nor fascicular block in the electrocardiogram was related to an increased death rate.

A diagnosis of 'cardiomyopathy' was made in 6 patients with evidence of important myocardial dysfunction. This difficult diagnosis was made pre-operatively in the presence of gross cardiomegaly or haemodynamic abnormality not explained by the valve lesion alone. Of 27 patients with CTR more than 0.65, 6 were considered to have cardiomyopathy. The aetiology was active rheumatic fever in 1 patient, diabetes and hypertension in 1, and advanced decompensated valvular disease in 4 patients. All survived to undergo surgery. Eight patients with systemic hypertension behaved no differently from others without hypertension, but the numbers were too small for proper comparison.

Symptomatic status

Six objective measurements correlated closely with symptomatic status at the time of review (Table 3), and there was a high level of association between many of these factors. Thus patients with large hearts tended to be those with heart failure and extreme left ventricular hypertrophy.

TABLE 3 Percentage of patients in each symptomatic class with significant objective factor

Factor	Symptomatic class			Significance		
	I	II	III and IV	P: I v II	P: I v III and IV	P: II v III and IV
CTR > 60	20	42	57	<0.05	<0.001	NS
Arrhythmia	5	37	41	<0.005	<0.001	NS
Extr. LVH	7	27	28	<0.005	<0.005	NS
LAD	7	30	50	<0.01	<0.0001	<0.01
Fasc. block	4	12	13	NS	<0.01	NS
Age > 40 yr	2	22	45	<0.01	<0.0001	<0.01

CTR=cardiothoracic ratio Extr. LVH=extreme left ventricular hypertrophy
LAD=left axis deviation Fasc. block=fascicular block
P: I v II etc.: probability that difference between I and II, etc. occurred by chance

FIG. 2 The incidence in patients coming to surgery of the factors which were found to affect symptomatic status. CTR 0.60+ = cardiothoracic ratio greater than 0.60; Ang = angina; HF = heart failure; Arrhy = arrhythmia; LAD = left axis deviation; FB = fascicular block; SLVH = severe left ventricular hypertrophy; ExLVH = extreme left ventricular hypertrophy.

B. Factors associated with higher incidence of surgical complications in patients who came to operation

One hundred and ten patients underwent aortic homograft replacement after a period of observation of 0 to 12 years (mean 2.3). The major clinical features of these patients are illustrated in Fig. 2. At the time of operation 10 were in Class I, 44 in Class II, and 56 were in Class III or IV.

Thirty-four patients developed surgical complications. These include myocardial damage (9 cases), significant aortic regurgitation soon after operation (16), myocardial damage plus aortic regurgitation (2), a conduction defect (1), a conduction defect plus aortic regurgitation (1), and hospital deaths (4).

Three of the 39 factors studied were associated with a higher surgical complication rate. These were: heart failure, a CTR more than 0.65, and the presence of a mitral lesion which had been considered minor. Changes in surgical technique can, however, account for the apparent influence of each of these factors. In December 1964, the surgical technique was modified by tailoring the aortic root when necessary to ensure a better fit of the donor valve (Barratt-Boyes and Roche, 1969). This resulted in a lower incidence of early homograft valve regurgitation. From about the same time, fewer patients were seen with end-stage disease, so that fewer patients had pronounced cardiomegaly or heart failure (78% before, compared with 40% after).

The association of a higher surgical complication rate with minor mitral valve disease was unexplained, though mitral valve lesions were also more common in the early period. It appeared, therefore,

that the relation of surgical complication rate with these 3 factors was spurious, and that surgical complications in this series were independent of preoperative status.

The 34 patients with an unsatisfactory operation were also assessed in regard to their symptomatic result. Four were good, 4 satisfactory, and 10 poor. There were 15 deaths (4 hospital and 11 late) and 1 patient was lost to follow-up.

Hospital deaths One patient (aged 13 years) had an emergency operation for terminal heart failure. Cardiac arrest occurred during the anaesthetic induction and he did not survive operation. The other 3 patients all died from surgical complications.

Late deaths Seven of the late deaths were related to homograft valve failure, caused either by cusp rupture, perivalvular suture line leak, or bacterial endocarditis. Preoperative factors may have played a role in the other 4 patients. One had congestive heart failure with angina, one cardiomyopathy, one extreme cardiomegaly (CTR=0.75), and one frequent ventricular premature beats.

C. Preoperative factors associated with unsatisfactory longer-term result after good operation

Seventy-six patients underwent an entirely satisfactory operation. The symptomatic result over a period of 1 to 3 years was good in 51 patients and satisfactory in 14. One patient with cardiomyopathy had persistent cardiomegaly despite successful surgery and was classified as a poor result. There were 8 late deaths in this group from 4 to 36 months after surgery and 2 further patients were lost to follow-up. Two late deaths resulted from bacterial endocarditis, but preoperative factors were thought to have contributed to the outcome in the other 6 patients. Two of these had a cardiomyopathy, 1 had cardiomegaly (CTR=0.78), and 2 underwent surgery in extreme heart failure. The final patient had had frequent ventricular premature beats preoperatively.

Cardiomyopathy, which was present in 6 patients before operation, appeared to be an important factor, which adversely influenced the long-term result. Three of these had entirely satisfactory operations but all did poorly. Two died and 1 had a poor long-term result. Cardiomegaly (CTR > 0.65) was present in 8 patients who had a satisfactory operation. Three of these subsequently died and are compared with 4 deaths among 62 patients with a CTR of less than 0.65. Striking cardiomegaly thus

appeared to be associated with a poorer longer-term result.

Four of 26 patients with a rhythm abnormality before operation died, and are compared with 4 deaths in 50 patients who had sinus rhythm. Rhythm abnormalities were more commonly associated with cardiomegaly and congestive heart failure, so that they did not appear to be important in themselves though they may have contributed to late death in some cases.

There was no evidence that preoperative angina had a deleterious effect. Of 31 patients with angina who underwent surgery, 26 had additional unfavourable features, but 27 of the 31 patients were well and free from angina after operation: the remaining 4 died late. One (who had an unsatisfactory operation) also had considerable congestive heart failure preoperatively, one had pronounced cardiomegaly ($CTR=0.75$), one had a cardiomyopathy, and one had frequent ventricular premature beats.

In summary, preoperative cardiomyopathy, a distinct degree of cardiomegaly ($CTR>0.65$), congestive heart failure at the time of operation, and ventricular premature beats were all associated with a poor longer-term result after satisfactory surgery, and probably contributed to poor results after satisfactory surgery. There was no evidence that preoperative angina, paroxysmal dyspnoea, or orthopnoea without persistent congestive heart failure had a deleterious effect on the longer-term result.

Discussion

A variable prognosis in patients with severe aortic regurgitation is well known and it is clearly important to establish logical criteria for operative intervention. This study has limitations inherent in all retrospective surveys, but nevertheless accurate historical data were obtained from a large number of patients. The development of surgical techniques for aortic valve replacement in the middle of the period under review limited its value as a study of the natural history of the untreated disease but allowed for an assessment of the influence of preoperative factors on postoperative outcome. Eight patients died before the advent of surgery and a number of patients had end-stage disease when surgery first became available.

The need for valve replacement is obvious in patients with distinct symptoms or advanced congestive heart failure, but the decision is more difficult in the reasonably compensated patient with mild or moderate symptomatic limitations. To provide a uniform group of patients, only those with severe aortic regurgitation on a rheumatic basis

were included. In this way, complications from additional factors such as medionecrosis of the aorta, syphilitic involvement of the coronary arteries, or important rheumatic involvement of other valves, were avoided.

In the Polynesian patients there is a high incidence of rheumatic heart disease and severe multivalve disease is common (New Zealand Department of Statistics, 1972). However, in the patient with 'isolated' aortic regurgitation, the clinical course is similar to that seen in the European counterpart.

Only 4 factors were associated with an increased incidence of preoperative deaths; heart failure, cardiomegaly ($CTR>0.60$), extreme left ventricular hypertrophy, and frequent ventricular premature beats. It is noteworthy that, though there was an association between symptomatic class and objective abnormalities (Table 3), clinical symptoms (shortness of breath, orthopnoea, paroxysmal nocturnal dyspnoea, or congestive heart failure) were not more common in patients who died. In particular, there was no evidence that angina (unassociated with other unfavourable features) predisposed to premature death. Of the 4 objective factors, only a CTR more than 0.60 provided an indication for surgery when other factors were absent.

No preoperative factor was shown to predispose to unsatisfactory surgery. Postoperative deaths unrelated to technical problems or to bacterial endocarditis were too few to permit statistical conclusion. However, the only likely preoperative contributory factors were cardiomyopathy (usually because of undue delay in surgery despite advanced heart failure), considerable cardiomegaly ($CTR>0.65$) and, on occasion, advanced congestive heart failure at the time of operation or frequent ventricular premature beats. This conclusion awaits confirmation from a longer follow-up period but though the recorded follow-up period is short, further clinical reviews have shown no evidence of important change in patient status.

An attempt to define the natural history of severe aortic regurgitation has been made in previous publications. In the group of rheumatic cases described by Segal, Harvey, and Huffnagel (1956) the average age at the first attack of rheumatic fever was 13 years, and the average age at the development of haemodynamically significant aortic regurgitation was 20 years. An asymptomatic period of 10.3 years was followed by a symptomatic period of 6.4 years at the time of the study. In those patients affected, congestive heart failure was present for an average of 6.6 years and angina for 4.6 years. It should be noted, however, that, as in the present study, most of these patients were referred for surgical assess-

ment and this may have excluded a number of patients who died prematurely. Even so, 5 per cent of the patients of Segal *et al.* (1956) died suddenly and unexpectedly. Similarly, Bland and Wheeler (1957) found that 37 per cent of their patients were able to lead relatively normal lives 10 years after the onset of aortic regurgitation and 26 per cent were well at 20 years. On the other hand, 38 per cent died within 10 years, and 56 per cent within 20 years.

The average time course of the disease will vary according to the method of selection of the group described. In the present study, a prolonged symptomatic period was relatively common, dyspnoea on exertion being noted for up to 20 years, symptoms of all three categories of heart failure for up to 10 years, and angina for up to 20 years. The prolonged survival of many patients with severe aortic regurgitation must be considered in deciding those features associated with a poor prognosis. DeGeorges and Delzant (1966) recorded a high death rate in patients who developed pulmonary oedema (9 out of 13 cases) or congestive heart failure (20 out of 24 cases). Massell, Amezcua, and Czoniczer (1966) reported the death of 13 out of 14 patients who developed congestive heart failure. Using a different approach Spagnuolo *et al.* (1971) defined the end point of the clinical course as the onset of angina, the onset of congestive heart failure, or death. They further defined a triad of (a) moderate or pronounced left ventricular hypertrophy radiologically, (b) two or three electrocardiographic abnormalities, and (c) an abnormal blood pressure with systolic pressure above 140 mmHg (18.6 kPa), or a diastolic pressure below 40 mmHg (5.3 kPa). We did not find the blood pressure significant in our group of patients, and we interpret Spagnuolo's results as indicating that an unfavourable outcome is related to the presence of severe left ventricular hypertrophy and important cardiac enlargement. This conclusion is in agreement with our own, but we believe measurement of CTR is preferable to a radiological attempt to assess left ventricular hypertrophy.

The onset of angina is usually considered a bad prognostic feature. Eight of the 9 patients with this symptom in the group described by Bland and Wheeler (1957) died within 2 years of onset and DeGeorges and Delzant (1966) reported average survival of 3 years in patients with angina. In these reports, the association of angina with other features received little attention. In the present series, all patients with angina who died without operation had additional unfavourable features, and the presence of preoperative angina did not affect early or late surgical results. Linhart *et al.* (1968) found significant coronary artery disease in 13 of 43 patients

with aortic regurgitation, but the average age of these patients was 58 years. Coronary artery disease did not appear to be a significant feature in our patients. Angina was virtually always a function of advanced aortic regurgitation but it did not, in itself, constitute an indication for surgical intervention.

Braun, Kincaid, and McGoon (1973) have described a poorer early and late prognosis after surgery in patients with a preoperative CTR more than 0.57. We found no influence on postoperative outcome until the CTR was more than 0.65, though 'unexpected' preoperative death occurred in occasional patients with a CTR between 0.60 and 0.65.

It is possible that serial measurements of myocardial function might improve the assessment of the optimal timing of surgery, though interpretation of such measurements poses particular difficulties in patients with aortic regurgitation. Where repeated observations are required, non-invasive assessment has obvious merits and the simpler clinical observations used in this study have allowed a surprisingly accurate prediction of outcome. It remains to be seen whether this can be improved by the use of more sophisticated measurements.

The surgical risk for a young patient with aortic regurgitation is low and follow-up studies allow for increasing confidence in the long-term results of valve replacement. Even so, surgery is not warranted when it can be safely postponed. For the average patient with long-standing aortic regurgitation the surgical indications appear relatively clear cut.

- 1) Peripheral signs of a severe aortic valve leak. The natural history of aortic regurgitation of moderate severity is outside the scope of this paper, but in such patients surgery is required only in the presence of other complicating features.
- 2) A CTR of greater than 0.60. Other unfavourable features are usually present, but cardiomegaly of this magnitude is, in itself, usually an indication for surgery.
- 3) A history of heart failure (orthopnoea, paroxysmal nocturnal dyspnoea, or congestive heart failure) together with electrocardiographic evidence of extreme left ventricular hypertrophy, provides an indication for operation even if the CTR is less than 0.60.
- 4) Ventricular premature beats are unfavourable but are not an indication for surgery unless other major features are present.
- 5) Independent evidence of myocardial disease.

There is no evidence that any of the other factors studied should influence a decision for surgical intervention, for neither unexpected death nor a poor

result after satisfactory surgery need be anticipated in the absence of the criteria outlined. Adherence to these criteria should, therefore, permit safe postponement of surgery in many cases. Admittedly, our patients constitute a selected group, but there is little published evidence of unexpected death in the absence of advanced disease. In the series of DeGeorges and Delzant (1966), death was preceded by signs of 'poor tolerance' in 30 out of 34 cases and the status of the other 4 patients was not known with certainty. A similar pattern is seen in the series of Spagnuolo *et al.* (1971). On the other hand, the mortality associated with the criteria described, suggests that surgery should not be delayed once these are fulfilled. Furthermore, the probable increase in surgical risk with emergency surgery on a patient *in extremis* and the unfavourable outcome after surgery in some patients with extreme cardiomegaly or advanced congestive heart failure preoperatively, are a clear enough indication that these situations should be avoided.

In the management of aortic regurgitation of non-rheumatic aetiology additional factors must be taken into consideration. Similarly, the situation is more complicated in the presence of important associated valvular anomalies.

References

- Barratt-Boyes, B. G. (1965). A method of preparing and inserting a homograft aortic valve. *British Journal of Surgery*, **52**, 847.
- Barratt-Boyes, B. G., and Roche, A. H. G. (1969). A review of aortic valve homografts over a six and one-half year period. *Annals of Surgery*, **170**, 483.
- Bland, E. F., and Wheeler, E. O. (1957). Severe aortic regurgitation in young people. *New England Journal of Medicine*, **256**, 667.
- Braun, L. O., Kincaid, O. W., and McGoon, D. C. (1973). Prognosis of aortic valve replacement in relation to the preoperative heart size. *Journal of Thoracic and Cardiovascular Surgery*, **65**, 381.
- DeGeorges, M., and Delzant, J. F. (1966). Éléments de pronostic de l'insuffisance aortique isolée recueillis chez 206 malades âgés de moins de 50 ans. *Semaine des Hôpitaux de Paris*, **42**, 1171.
- Goldstein, A. (1964). *Biostatistics: An Introductory Text*, p. 101. Macmillan, New York.
- Judge, T. P., and Kennedy, J. W. (1970). Estimation of aortic regurgitation by diastolic pulse wave analysis. *Circulation*, **41**, 659.
- Linhart, J. W., de la Torre, A., Ramsey, H. W., and Wheat, M. W., Jr. (1968). The significance of coronary artery disease in aortic valve replacement. *Journal of Thoracic and Cardiovascular Surgery*, **55**, 811.
- Massell, B. F., Amezcua, F. J., and Czoniczer, G. (1966). Prognosis of patients with pure or predominant aortic regurgitation in the absence of surgery. *Circulation*, **34**, Suppl. 3, 164.
- New York Heart Association (1964). *Diseases of the Heart and Blood Vessels: Nomenclature and Criteria for Diagnosis*, 6th ed., p. 112. Little, Brown, Boston.
- New Zealand, Department of Statistics (1972). Death by causes. In *New Zealand Official Year Book*, Vol. 77, p. 101. Department of Statistics, Wellington, New Zealand.
- Segal, J., Harvey, W. P., and Huffnagel, C. (1956). A clinical study of one hundred cases of severe aortic insufficiency. *American Journal of Medicine*, **21**, 200.
- Spagnuolo, M., Kloth, H., Taranta, A., Dotle, E., and Pasternack, B. (1971). Natural history of rheumatic aortic regurgitation. *Circulation*, **44**, 368.

Requests for reprints to Dr. J. M. Neutze, Cardiology Department, Green Lane Hospital, Auckland 3, New Zealand.

been blocked by the Dept. of Health and Social Security.

Nevertheless in their letter Dr. Harrison and his colleagues show that in Tampa only 23 per cent of the patients with ventricular fibrillation upon whom resuscitation was attempted had a successful outcome. It is surely not inaccurate to describe such a success as 'limited'—however much one may admire it, as we indeed do. To save the 77 out

of every 100 who died, a different approach from that of mobile coronary care is needed. It is arguable that the total disappearance of the habit of cigarette smoking for example might save more lives than any coronary care unit whether mobile or stationary.

A. Myers and H. A. Dewar,
The Royal Victoria Infirmary,
Newcastle upon Tyne.

Erratum

In the paper 'The Natural History of rheumatic, aortic regurgitation and indications for surgery', which appeared on pp 147-154, line 19, p. 147, column 2 should read—'Fifty-three patients with moderate aortic regurgitation and 67 patients with moderate or severe aortic regurgitation of non-rheumatic aetiology referred during the same period were also excluded from the study'.