Reoperation for angina after previous aortocoronary bypass surgery

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SUMMARY A retrospective study was carried out of the outcome of 102 patients who underwent a second operation for myocardial revascularisation, necessitated by persistence or recurrence of intractable angina after their first coronary bypass procedures. Operative mortality was 2%. During follow up of the survivors (mean interval 36.4 months) five died, two after further operation, and five underwent further surgery. Sixty eight patients reported an improvement in their symptoms, 57 of whom claimed to have little or no angina. Less favourable results were recorded for those patients reviewed with longer follow up. No useful indicators of prognosis were identified.

The problem of angina in patients who have already received bypass grafts is likely to increase as more revascularisation surgery is performed. Reoperation offers a reasonable prospect of helping some of these patients, but not all will be suitable. Their long term prognosis remains uncertain.

Bypass graft surgery ameliorates or abolishes angina in the majority of patients who undergo operation,¹ but in some cases symptoms persist or recur. Angina may recur in 3.5-4.4% of patients each year.² Thus as more patients have undergone bypass surgery, and as the time elapsing after operation increases, the problem of angina in patients who have already undergone one myocardial revascularisation procedure will increase. Reoperation can be performed with a low risk and can improve or relieve angina in many patients, but the late results are less favourable than after the first attempt at revascularisation.³

The results of reoperations at the London Chest Hospital were reported in 1979.⁴ We now report our further experience with a larger series of patients and the results of extended follow up of those who underwent operation initially. We sought to identify factors, which can be determined preoperatively, that may give an indication of the prognosis after reoperation.

Patients and methods

One hundred and two patients who underwent a

second coronary bypass operation between 1972 and January 1982 were included in the study. Patients who had concurrent valve surgery were not included. The mean age of the patients was 52.7 (range 34-73) years. Nine patients were female. Nine were known to have diabetes mellitus and 19 hypertension, and 33 smoked >10 cigarettes a day at the time of reoperation. Serum cholesterol concentration was estimated in 58 patients and was found to be increased (>7.0 mmol/l (>300 mg/100 ml)) in 29.

FIRST OPERATION

At the first operation a mean of 2.1 grafts were placed per patient. Twenty seven patients received one graft, 39 two, 33 three, and three four. In addition 24 patients had endarterectomy performed to 33 vessels. Left ventricular aneurysmectomy was carried out in two patients. Twelve patients were considered to have had perioperative myocardial infarction as assessed by electrocardiographic criteria (development of pathological Q waves in nine or of bundle branch block in three). Table 1 gives details of the sites of graft placement.

RECURRENT ANGINA

The clinical indication for considering reoperation in all patients was severe angina either at rest or on minimal exertion which had proved refractory to medical management. All patients were investigated by selective coronary and graft angiography in three planes

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Table 1 Sites of graft placement at first operations and reoperation. Figures indicate number of patients

Graft site	First operation	Reoperation	
		New grafts	Regrafts
Left anterior descending artery (LAD)	76	13	44
Diagonal of LAD	14	2	7
Lateral circumflex branches	45 (3*)	43	21
Trifurcation branch	4	1	1
Right coronary artery before crux (RCA)	45	14	25
Posterior descending artery (PDA)	11	10	16†

*Patients who had grafts to two lateral circumflex branches.

†Includes patients in whom a RCA graft was placed before the crux at first operation and to the PDA at reoperation.

and left ventricular angiography in the right anterior oblique plane. Only those patients in whom it was technically feasible to place further grafts, and who therefore underwent surgery, are reported in this study.

The putative cause for the recurrence of angina was determined from the angiogram. Where a graft was occluded or significantly stenosed, or distortion at its insertion into the coronary artery was equivalent to such a stenosis, the graft was deemed to have failed. Progressive disease describes the development of a stenosis of >50% that was not apparent on the angiogram before the first operation. Revascularisation was considered to have been incomplete at the first operation if a vessel was not bypassed when it contained a stenosis of >50%. The terms progressive disease and incomplete revascularisation were applied only to vessels whose lumen diameter was >1 mm on the basis that the smaller vessels would be unsuitable to receive a vein graft.^{5 6} The cause of recurrent angina was then categorised as (a) graft failure, (b) progressive disease, (c) incomplete revascularisation, or (d) various combinations of these factors.

REOPERATION

All the reoperations reported in this series were performed at the London Chest Hospital by one of three surgeons. The mean interval between the first and second operation was 37.1 (SD±28.6) months.

FOLLOW UP

The progress of patients during follow up after reoperation was assessed as far as possible from clinic attendances. For patients unable to attend the hospital information was obtained from questionnaires sent to the patients themselves, from their attending physicians, and from their general practitioners. Inquiry was made about the presence and severity of angina, which was graded as: 0, no angina; 1, angina occurring only on severe exertion; 2, angina occurring on moderate exertion; 3, angina occurring on minor degrees of exertion; and 4, angina at rest. Symptoms and signs of left ventricular failure were sought. The

medication taken by the patients was recorded.

In 47 patients maximal symptom limited progressive increment exercise testing was performed either by treadmill (modified Bruce protocol) or by bicycle ergometer. The reason for termination of the test, the maximum workload achieved, and the electrocardiographic changes were noted. Of these patients, 24 had previously performed an exercise test before reoperation so that a comparison between results was possible. The end point for follow up was the latest available clinical information—unless a further surgical procedure for revascularisation had been performed, when this was taken as the end point—or death. For the purposes of stratifying the patients into groups according to the length of follow up, the duration of follow up was taken from the time of reoperation until December 1982 for those patients who underwent further reoperation or who had died. Inquiry was made to the Registrar General at this date to ascertain if any patient had died, so that we consider that the survival data are complete.

Results

CAUSE OF RECURRENT ANGINA AFTER FIRST OPERATION

Table 2 shows the angiographic features thought to indicate the reason for recurrent angina and the time of this recurrence in the different groups. Overall, graft failure was considered to have occurred in 84 patients, progressive disease in 42, and revascularisation to have been incomplete in 34. Of the 27 patients who received a single graft at the first operation, revascularisation was considered incomplete in 10. For the remaining 17 patients a single graft was the appropriate procedure, and in only two of these was failure of this graft the sole cause of recurrent angina.

REOPERATION

At reoperation the mean number of grafts placed per patient was 1.97. Table 1 shows the distribution of

Table 2 Putative cause(s) of recurrent angina after first operation and mean (SD) time until recurrent angina in each group

Cause(s) of recurrent angina	No of patients	Time of recurrence after first operation (month)
Graft failure only	31	11.1 (17.6)
Progressive disease only	12	20.9 (17.3)
Incomplete revascularisation only	3	4.3 —
Graft failure and incomplete revascularisation	24	18.1 (25.9)
Graft failure and progressive disease	23	30.7 (21.1)
Incomplete revascularisation and progressive disease	1	
Incomplete revascularisation, progressive disease, and graft failure	6	27.7 —
Not determined	2	

these grafts. Twenty nine patients received one graft, 49 two grafts, 23 three grafts, and one four grafts. Endarterectomy was performed on 24 vessels in 18 patients, four of whom had already had vessels endarterectomised at their first operation.

Twenty two patients received grafts only to vessels that had not been grafted at the first operation, 33 received grafts only to vessels that had previously received grafts, and the remaining 47 patients had a combined procedure. The term "vessel" refers to all coronary branches of sufficient size to accept a vein graft. In this context, for example, the diagonal branch of the left anterior descending artery if large enough to graft, would be considered a separate vessel to the main left anterior descending artery.

There were two operative deaths, and eight patients had perioperative myocardial infarction (new Q waves in six, bundle branch block in two). Table 3 lists the recorded complications. Of particular note, two patients suffered division of a previously placed graft to the left anterior descending artery during re-sternotomy. One of these patients developed an anterior myocardial infarction and later died of left ventricular failure, and the other died in the immediate post-operative period.

FOLLOW UP

Information was available on all 100 survivors at a mean interval of 36.4 (range 2–86) months. During follow up three patients died at three, 38, and 40 months without further surgery. Five patients pro-

ceeded to a third operation for myocardial revascularisation, and one underwent dilatation of his grafts during cardiopulmonary bypass. Two of these patients undergoing further surgery also subsequently died, and in one the cause of death was attributed to leukaemia. One other patient received a cardiac transplant. Sixty eight patients thought that their symptoms were improved, 14 that their condition was unchanged, and the remaining 13 survivors that their symptoms had become worse.

For the following analyses the patients were divided into three groups according to their outcome:

Good result—This group comprised patients who had no angina or angina only on severe exertion (grades 0 and 1).

Intermediate result—This group comprised patients with angina on moderate exertion (grade 2).

Poor result—This group comprised patients who died, required a further operative procedure, developed severe left ventricular failure, or had angina on minimal exertion or at rest (grades 3 and 4). On the basis of these criteria 57 patients derived great benefit from their reoperation, 14 fell into the intermediate group, and 31 fared badly.

The type of operative procedure did not influence outcome. Good results were obtained in 52% of patients who had vessels regrafted only, in 59% of those who received only new grafts, and in 57% of those undergoing a combined procedure (Fig. 1). Results for outcome were less favourable for patients whose duration of follow up was 24 months or more compared with those who were reviewed earlier (Fig. 2). Tables 4 and 5 show the influence on outcome of a number of factors either determined before reoperation or which were a feature of the operations. The assessment of completeness of revascularisation at reoperation took account of vessels that were considered large enough to graft (>1.0 mm) (Table 5). Neither the cause of recurrent angina after the first operation nor the interval to that recurrence influenced outcome significantly. There was, however, a trend for this interval to be shorter in those patients whose outcome was unsatisfactory. When patients in whom incomplete revascularisation at the first operation was considered a contributory factor

Table 3 Numbers of patients in whom recorded operative complications occurred

Death (within 24 hours)	2
Myocardial infarction	8
Resternotomy for bleeding	3
Other significant bleeding problems	2
Slow wound healing/dehiscence	3
Division of LAD graft at sternotomy (one died, included above)	2
Transient atrial fibrillation or flutter	6
Others*	6

*One instance each of renal failure, pulmonary embolism, haematuria with anticoagulants, ventricular fibrillation, thigh abscess, tear in superior vena cava.
LAD, left anterior descending artery.

Fig. 1 Outcome according to the type of operative procedure. Regraft only: patients in whom grafts were placed only in previously grafted vessels; new grafts only: patients in whom grafts were placed only into ungrafted vessels.

Fig. 2 Comparison of outcome in patients with early (< 24 months) and late (> 24 months) follow up.

Table 4 Distribution of factors, which may be determined before reoperation, in the three groups divided according to the result of reoperation. Figures (except for age) indicate number of patients

Condition	No of patients	Outcome after reoperation		
		Good	Intermediate	Poor
Total	102	57	14	31
Age (y)	102	52.9	52.5	52.1
Male	93	51	14	28
Diabetes	9	2	2	5
Smoking	34	19	7	8
Hypertension	20	11	1	8
Hypercholesterolaemia	29/53*	15/28	9/10	5/15

*Number of patients with hypercholesterolaemia out of number of patients in whom serum cholesterol concentration was measured.

Table 5 Distribution of features of first operations and reoperations among the three groups divided according to result of reoperation

Surgical factors	No of patients	Outcome after reoperation		
		Good	Intermediate	Poor
Total	102	57	14	31
Endarterectomy:				
First operation	24	14	6	4
Reoperation	18	9	5	4
Mean number of grafts placed per patient (n=102):				
First operation		2.12	2.33	2.0
Reoperation		2.00	2.20	1.77
Revascularisation at reoperation (n=100):*				
Complete	61	34	10	17
Incomplete	39	21	4	14

*Not determined with certainty in two patients.

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for recurrent angina were excluded, recurrence occurred at a mean interval of 25.4 (SD±22.5) months for those whose outcome was good and of 17.0 (19.9) months for those who fared poorly after reoperation. Patients in whom incomplete revascularisation was implicated as a cause for recurrence fared slightly better after reoperation than those whose first operations were considered complete.

Exercise tests were performed in 47 subjects at a mean interval after reoperation of 29.8 months. Twenty three patients achieved ≥450 kpm on the bicycle ergometer, and seven ≥ stage 3 of the modified Bruce protocol on the treadmill. Twenty four patients also had preoperative tests. After reoperation 10 patients achieved a higher workload, six the same, and eight only a lower maximum.

At follow up 53% of patients were receiving beta blocking drugs and 50% nitrates regularly.

Discussion

The majority of patients in this and other reported studies underwent reoperation for the persistence or recurrence of severe angina. The results of reoperation do not seem to have been compared with those of continuing medical management in this situation. Nevertheless, as angina had proved refractory to optimal medical treatment, often for many months, the symptoms would probably not have resolved spontaneously in an appreciable number of patients

without reoperation. Reoperation can be performed with a relatively low mortality (Table 6), which it nevertheless higher than for first operations,¹ and the risk of complications also tends to be higher. The most notable problems relate to re sternotomy, when a previously placed graft to the left anterior descending artery is at risk.^{11 12} Up to 10% of patients may require further re sternotomy for postoperative bleeding.³

Most patients in reported series derive benefit from further revascularisation, but often only a few gain complete relief from angina (Table 6). Our results are similar. Reoperation is usually regarded as a symptomatic measure, and it is therefore appropriate to assess the outcome in terms of patients' subjective description of their symptoms. This assessment does not always yield a clearly defined end point, and the patients' perception of their symptoms may also depend on many extraneous influences, such as depression or inappropriate expectations. For these reasons we attempted to make an objective assessment by formal examination of exercise performance, although we recognise that the maximum workload is also dependent on the patient's co-operation and enthusiasm. Table 7 shows the relation between the maximum exercise workloads achieved and the patient's subjective assessment of symptoms. It is a matter of interpretation which means of expressing the outcome is the more valid. Our exercise test data are incomplete. It was clinical policy at this centre not

Table 6 Figures for survival and outcome after reoperation derived from series published between 1978 and 1983. Figures marked with + are percentages of surviving patients

Centre	No of patients in study	Mean follow up interval	Survival (%)	Minimal or no angina (%)	Satisfactory outcome (%)
Cleveland ³	500	5 yr	89	60	89
Houston ⁷	168	6 yr	82	—	84+
Mayo Clinic ⁸	106	43 mnth	91	28	63 (at 5 years)
Los Angeles ⁹	79	32 mnth	86	38	71
Portland ¹⁰	79	2 yr	95	—	88
Ottawa ¹¹	74	23 mnth	97	52	77
Stanford ¹²	71	2.2 yr	89	27	59
Rotterdam ¹³	53	3.5 yr	91	35	88
New York ¹⁴	48	—	88	86	90+
Montreal ¹⁵	43	30 mnth	95	—	85 (symptomatic patients)
Washington ¹⁶	40	6 mnth to 6 yr	98	23	83
Hammersmith ¹⁷	34	18 mnth	97	42	69

Table 7 Comparison between the results of postoperative exercise testing and patients' subjective assessment of their symptoms after reoperation

Symptomatic outcome	Maximum workload (kpm (treadmill stage))			
	300 (1)	450 (2)	600 (3)	750 (>4)
Good	5	7	9	6
Intermediate	1	4	2	—
Poor	6	4	3	—

to subject patients who had angina at rest to exercise testing, and many patients fell into this category. Many patients lived at considerable distance from the hospital and were not available for postoperative testing.

The position regarding symptomless patients, in whom angiography postoperatively shows unsatisfactory revascularisation, is less clear. Reported results are conflicting.¹¹⁻¹⁵ At present the usual clinical practice is to consider reoperation only in patients with symptoms.

The age and sex distribution and incidence of diabetes, smoking, hyperlipidaemia, and hypertension are typical of those reported elsewhere.⁷ An appreciation of any factors which presage a good or poor outcome would be valuable to clinical management. It was disappointing in this study that no such factors clearly emerged. We failed to find any influence of the cause of recurrent angina after first operation on outcome, which is in agreement with several other studies,⁸⁻¹⁰ although Laird-Meeter *et al* found that patients with failed grafts fared worse than those with progressive disease.¹³ The data shown here of our current and expanded experience do not confirm the earlier observation⁴ that patients who receive grafts only to previously ungrafted vessels fare better than those requiring grafts to vessels already grafted. We noted a slight trend for a shorter interval to recurrence of angina to correlate with a poorer outcome, and a significant such correlation is reported by Krause *et al*.¹⁰ This observation could be explained by postulating more aggressive coronary disease in these patients. Patients whose recurrence is attributable to graft failure tend to have an earlier return of angina than those whose cause is progressive disease,^{3,17} but in all cases angiography remains mandatory for anyone in whom reoperation is contemplated.

An assessment of the completeness of revascularisation at reoperation did not help determine outcome, perhaps because vessels considered to be too small to graft were not included in the analysis. Such small vessels might still be responsible for further symptoms.

Patients requiring reoperation have a high incidence of risk factors.¹⁸ Although these do not usually exert any adverse influence on outcome after reoperation,¹⁰ it seems prudent to give firm advice to abstain from smoking. We found diabetes over-represented in the group who fared poorly after reoperation, but the numbers are too small to derive statistical inference. Diabetes has a mildly deleterious effect on outcome after primary revascularisation, which is not considered sufficiently adverse to disbar diabetics from surgery.^{19,20}

Our results in patients with longer follow up are less encouraging (Fig. 2). The interval over which

patients are studied may not be the only determinant of outcome. Those with longest follow up are also those reoperated on earlier in the series, when experience in the procedure was less and selection criteria may have varied. The earlier patients (more than two years' follow up) had fewer grafts inserted at their first operations (mean 1.92/patient) than the later patients (2.35/patient). For these later patients to receive only grafts to ungrafted vessels was unusual. Reported experience of long term results after reoperation remains limited (Table 6).

This report includes a relatively high proportion of single vein graft procedures (27) at primary revascularisation, but 10 of these patients required more than one graft. Most of these incomplete operations date from early in the series, and current practice is to attempt complete revascularisation. There is theoretical concern that patients who require surgery for intractable symptoms with single vessel disease may have a poorly developed collateral circulation which makes them susceptible to recurrence of angina if their sole graft ceases to function. In practice patients with single grafts are more prone to recurrence.³ In our report only two patients underwent reoperation when failure of a single graft was the only cause of returning angina. Our experience is that the main risk for patients with single grafts is the development or progression of stenoses in ungrafted vessels. In future angioplasty may defer the need for surgery until multiple grafts are required.

The strategy for the surgical management of coronary artery disease must take cognisance of the increasing likelihood of recurrent angina as time elapses after initial revascularisation. In this study we detected a similar trend after reoperation. It seems intuitively probable that factors that militate against a successful outcome to the first procedure may be operative after further surgery. It is premature to establish the role of third procedures, although results can be expected to be less promising than after first or second operations. Not all patients with recurrent angina will be suitable for reoperation; experience relates only to those in whom surgery appears technically feasible, which may comprise only a third of the total.¹³ Progression of minor stenoses to those of haemodynamic importance has been reported,⁹ and this evidence has been cited to indicate the need to bypass them at first operation to obviate the need for later revascularisation. Current practice is to place more grafts than was formerly usual.

Surgical management may be viewed as a series of palliative procedures, initially highly successful, in an inexorably progressive disease. The reasonable expectation of further improvement of symptoms, possibly for many years if severe angina recurs, remains a worthwhile objective, which can be achieved at low

risk by reoperation when angiography shows that surgery is technically feasible.

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