Reoperation for recurrent angina

N. BROOKS, M. HONEY, M. CATTELL, J. E. C. WRIGHT, M. F. STURRIDGE, R. BALCON, AND C. LAYTON

From the Cardiac Department, The London Chest Hospital, Bonner Road, London

SUMMARY Forty patients with persistent or recurrent angina after an aortocoronary bypass procedure underwent a second operation. The cause of recurrent angina, defined by angiography, was thought to be isolated graft failure in 13 patients, progression of disease in ungrafted vessels in 4, incomplete revascularisation in 2, and stenoses distal to patent grafts in 1. More than one factor was responsible in 20 patients.

There was 1 early postoperative death and 3 perioperative myocardial infarctions. Thirty-four patients have been followed for more than 3 months (4 to 63 months). Of these, 17 had previously bypassed vessels regrafted and 5 are symptom free, 4 have mild angina, and 8 have severe angina. Ten patients had previously ungrafted vessels grafted and 4 are symptom free, 3 have mild angina, 2 have severe angina, and 1 is limited by breathlessness. Seven patients had a combined procedure and 4 are symptom free, 1 has mild angina, and 2 have severe angina.

Reoperation can be carried out safely but the results are less satisfactory than for a primary procedure.

Aortocoronary bypass surgery abolishes or improves angina in most patients (Cooley *et al.*, 1973; Assad-Morrell *et al.*, 1975; Donaldson *et al.*, 1978). In some, however, the operation is unsuccessful, while in others angina recurs after an initially good result. With the large number of such operations currently being carried out in the United Kingdom, this minority with persistent or recurrent angina comprises an increasingly large number of patients. Many can be managed satisfactorily with conservative measures, but in some cases intractable symptoms present a difficult therapeutic problem and a second operation has to be considered. This paper describes our experience with 40 second myocardial revascularisation operations carried out at the London Chest Hospital since 1973.

Patients

The 40 patients, 37 men and 3 women aged between 34 and 66, had all had a coronary artery bypass operation; patients with a previous Vineberg procedure are not included. Nine had had a single graft, 21 a double graft, 9 a triple graft, and 1 a quadruple graft. Saphenous vein had been used as the conduit in all cases except for 1 in which the internal mammary artery had been implanted. Endarterectomy was employed in addition to

grafting in 7 patients on a total of 13 arteries. One patient had had a left ventricular aneurysm excised in addition to grafting.

Angina recurred from the early postoperative period (that is as soon as the patient was sufficiently mobile to develop effort angina) up to 54 months after operation. It was graded in severity on a scale of 1 to 4, in which grade 1 is angina occurring only with severe exertion, grade 2 is angina during normal activities, grade 3 is angina with minimal exertion or provoked by emotional disturbances, and grade 4 is angina at rest. At the time of the second operation 9 patients had grade 2 angina, 20 had grade 3, and 11 grade 4.

CAUSE OF RECURRENT ANGINA

Selective graft and coronary angiography was carried out to determine the state of grafts and of native coronary circulation. Left ventricular function was assessed from a single plane (RAO) left ventriculogram: ejection fraction was determined by the area-length method (Sandler and Dodge, 1968) using a planimeter, and the 3 wall regions (anterior, apical, and inferior) were described as showing normal or abnormal movement in systole. The findings were compared with the preoperative angiogram.

The causes of recurrent or persistent angina, occurring singly or in combination, were identified

as occlusion or stenosis of one or more grafts ('graft failure'), the persistence of significant narrowings in major ungrafted vessels ('incomplete revascularisation'), the development of new stenoses or occlusions in major ungrafted arteries ('progression of disease'), and the presence of occlusion or stenosis beyond the distal anastomosis of patent grafts. In the last group it was usually difficult to judge whether the graft had been placed too proximally or whether disease had progressed since operation, particularly in those in whom the grafted vessel was occluded on the preoperative angiogram.

In 13 patients graft failure alone was thought to be the cause of recurrent angina, 2 were judged to have had an incomplete first operation, and 4 had satisfactory grafts but new disease in major ungrafted vessels. One patient's poor result was attributable solely to the presence of severe stenoses distal to the insertion of 2 of his 3 grafts. Nine patients had graft failure combined with an incomplete first operation, 8 had a combination of graft failure and new disease, and 2 had graft failure in association with disease distal to patent grafts. One patient (case 24) had an incomplete first operation and in addition a new stenosis in an ungrafted artery and disease distal to an otherwise satisfactory graft.

With 1 exception, all patients with an incomplete first operation, alone or in combination with other factors, developed recurrent angina within a year. The single late recurrence was in a patient (case 24) who, in addition, had stenoses distal to a patent graft and progressive disease. One patient (case 34) had an occluded graft plus disease in 2 vessels which it had not been thought feasible to graft at the first operation; he had continued to have mild angina for 30 months and then abruptly deteriorated. Since the native circulation had not changed it was concluded that late graft occlusion was responsible for his recurrent severe symptoms. Patients with progressive disease developed recurrent angina as early as 3 months after operation. In patients with graft failure angina recurred from the early postoperative period up to 42 months after operation.

In 1 patient (case 23) left ventricular function before the second operation was better than before the first: a region of akinesia in relation to a blocked anterior descending artery contracted normally in the presence of a satisfactory graft. The patient who had a left ventricular aneurysm excised at the first operation (case 38) had an almost identical ejection fraction before the second. In 6 patients left ventricular function had deteriorated since the first operation with the development of new regions of abnormal wall motion. This was related to blocked or narrowed grafts in 4 patients (1 of whom had a

left ventricular aneurysm) and to a diseased ungrafted artery in 2. Four patients (excluding the one with an aneurysm) had an ejection fraction of 40 per cent or less; in 1 it was 25 per cent. Ten patients had normal left ventricular function at the time of the second operation, 26 had 1 area of abnormal wall motion, and 4 had more than 1 abnormal region. None had significant mitral regurgitation.

Four patients had diabetes mellitus, 5 were receiving treatment for hypertension, and 13 admitted to smoking more than 10 cigarettes a day up to the time of the second operation. Determination of fasting blood lipids and lipoprotein electrophoresis were carried out in 28 patients. Hyperlipoproteinaemia was detected in 10: 4 had type IIA (Fredrickson), 2 type IIB, and 4 type IV.

SURGICAL TECHNIQUE

The average time between the first and second operations was 22.7 months and ranged from 6 to 72 months.

Reoperation was done using cardiopulmonary bypass in 39 patients; in 35 this was combined with intermittent ischaemic arrest (ventricular fibrillation and aortic cross-clamping) allowing the temperature to drift down to 30°C. In 4 patients hypothermic arrest was produced by perfusion of the aortic root with cold Hartman's solution. In 1 patient the only procedure was the insertion of a bypass graft between the aorta and an existing graft and cardiopulmonary bypass was not required. Aortic cannulation was used routinely but in 1 patient emergency femoro-femoral bypass was established after the division of a graft to the left anterior descending artery while the chest was being opened.

In 17 patients (cases 1 to 17) the only procedure was regrafting of previously grafted vessels or revision of existing grafts. Twenty-three ordinary grafts were implanted, 3 grafts with more than 1 distal anastomosis ('snake grafts'), and 2 grafts between the aorta and an existing graft occluded at its proximal end. In 1 patient arm vein had to be used; suitable leg vein was found for all the others. Endarterectomy was carried out on 8 arteries and in 2 of these the vessel was closed with a vein patch as well as a graft. Thirteen patients (cases 18 to 30) had grafts placed to previously ungrafted arteries. A total of 17 vessels were bypassed and endarterectomy was carried out on 3. One patient in this group had an anteroapical left ventricular aneurysm excised in addition to grafting. Ten patients (cases 31 to 40) had combined procedures involving both regrafting of or revision of grafts to previously grafted vessels and the bypassing of arteries for the

first time. A total of 22 grafts were implanted in this group, including 1 snake graft. Endarterectomy was carried out on 5 vessels. In 1 patient in this group it was possible to reimplant the top end of a graft which had occluded at the proximal anastomosis.

Discrepancies between the cause of recurrent angina diagnosed angiographically and the actual operation carried out on certain patients are explained by the fact that it was not always possible to graft or regraft vessels with severe diffuse disease, and in 1 patient an apparently large stenosed circumflex artery could not be found.

SURGICAL COMPLICATIONS

There was one early postoperative death from left ventricular failure and necropsy showed widespread infarction of the left ventricle. This patient had severely impaired myocardial function before the second operation (ejection fraction 25%) and required extensive endarterectomy. Of the 39 survivors, 3 had definite electrocardiographic evidence of perioperative myocardial infarction in the form of new Q waves: one was the patient whose left anterior descending graft was divided during exposure of the heart. None of the patients had to return to the operating theatre for control of excessive postoperative bleeding.

Results of reoperation

The important details of the first operation, the cause of recurrent angina, the procedure at the second operation, and follow-up of each patient are given in Table 1.

Five patients had their second operation within the last 3 months, and though none has developed recurrent angina it is clearly too soon to make a realistic assessment of the result; they have therefore been excluded from further analysis. The remaining 34 survivors had their operation between 4 and 63 months ago; follow-up is complete to July 1978.

There have been no late deaths or documented myocardial infarctions. Only 13 patients are symptom free. A further 8 are reasonably satisfied with their result in that though they still have angina, it occurs only with unusual exertion (grade 1). One of the patients who had a perioperative myocardial infarction (case 22) has no pain but is limited by breathlessness on exertion. Twelve patients continue to suffer from severe angina.

The results of each main type of operative procedure are given in Table 2. Of the 17 patients in whom previously grafted vessels were revised the operation was of no benefit in 8. Five are

symptom free and 4 have mild angina. By contrast, 7 of the 10 patients who had grafts to previously ungrafted vessels and 5 of the 7 who had a combined procedure were improved by their second operation, with 8 symptom free and a further 4 with only mild residual angina.

Eight patients with angina, which was persistent or recurrent after a second operation, have been re-catheterised. Five out of 10 grafts into previously grafted vessels were found to be occluded and the 5 patent grafts are all unsatisfactory with poor peripheral run-off. All 5 grafts to previously un-bypassed vessels remain patent, though 1 has a poor run-off and another, in a patient whose first operation was incomplete (case 19), has no peripheral run-off at all as a result of occlusion of the artery at the site of anastomosis; this patient also has an important vessel with a major proximal stenosis which was left ungrafted at both operations. One patient with persistent pain has 4 patent grafts and the cause of his recurrent symptoms is not understood. All the grafts in 1 patient (case 13) have occluded and he has undergone a third operation, again without relief of his angina.

Discussion

The difficulties of a second heart operation are well known and relate mainly to the problems of exposure and haemostasis resulting from adhesions from the first procedure. Our experience indicates that this need not cause an unduly high complication rate. In only 1 patient did morbidity result directly from the difficult exposure when his functioning left anterior descending graft was divided; he had an infarct despite the institution of emergency cardiopulmonary bypass and repair of the damage. The mortality (1 out of 40) is close to that which can be achieved with a first operation and the single death was related perhaps more to the type of operative procedure (extensive endarterectomy in the presence of an already poorly functioning ventricle) than to the fact that it was the patient's second bypass operation.

Overall, the long-term results are disappointing, with a third of the patients followed for more than 3 months deriving no benefit from the second procedure and only a third symptom free. In particular patients in whom the only identifiable cause of recurrent angina was failure of previous grafts did badly. Similar results were reported after 21 reoperations carried out at Stanford University (Winkle *et al.*, 1975). It is easy to understand that if a technically skilful first operation is followed by graft occlusion the same factors which caused the primary failure will militate against a successful

Table 1 *Details of patients*

Case no.	Age (y)	First operation	Recurrent Time	AP Grade	Cause of recurrence	Second operation	Follow-up	Angina grade	Comments
1	53	Inf. LV, LCx LAD grafts	3/12	3	All grafts occl.	LAD, RCA grafts RCA-PDA LAD end.; vein patch LAD	30/12	3	Unable to regraft Cx
2	49	RCA LCx LAD grafts; LAD end.	3/12	3	Cx graft occl. distal LAD occl.	Distal LAD graft	21/12	3	Unable to regraft Cx
3	43	LAD LCx grafts; LCx end.	14/12	3	All grafts occl.	LAD graft	15/12	4	Unable to regraft Cx
4	56	RCA LAD LCx grafts	4/12	3	LAD graft occl. proximally	Graft to LAD graft	4/12	0	
5	43	LCx LAD grafts	6/12	4	Cx graft occl.	LCx graft	9/12	0	
6	35	LMCA RCA LCx grafts; LMCA LAD RCA PDA LCx end.	2/12	2	Stenosis distal to RCA and LCx grafts	LAD distal RCA and LCx grafts	16/12	2	Reinvestigation: poor run-off from all grafts
7	64	PDA LAD LCx grafts	1/52	2	LAD and PDA grafts occl.	RCA-PDA snake, LAD graft	10/12	1	Poor vein first op.; arm vein second op.
8	58	RCA LCx grafts	3/12	3	Cx graft occl. RCA graft stenosed	LCx RCA grafts	12/12	1	
9	47	LAD PDA grafts	2/12	2	Both grafts occl.; old LCx stenosis	RCA LAD grafts; RCA LAD end.; LAD vein patch	33/12	1	Poor vein first op.; unable to graft Cx
10	57	RCA LAD AVCx grafts; diagonal end.	24/12	4	RCA and Cx grafts occl.; stenosis distal LAD	RCA graft	11/12	0	
11	58	RCA diagonal grafts	22/12	4	RCA graft stenosis	Graft to RCA graft	27/12	0	Cardiopulmonary bypass not req.; ? stenosis due to fibrosis where RA appendage excised
12	63	RCA LAD LCx grafts; RCA and LCx end.	12/12	3	RCA and LAD grafts occl.	RCA LAD grafts	6/12	0	Poor LV—EF 30%
13	62	RCA LCx grafts	25/12	3	Both grafts occl.	RCA graft MCx-LCx snake RCA MCx end.	25/12	4	Reinvestigation: all grafts occl.; third op. no improvement
14	66	RCA LAD LCx grafts	5/12	3	All grafts occl.	RCA LAD LCx grafts. RCA LCx end.	8/12	1	Poor vein at first op.
15	65	LAD LCx grafts	5/12	3	Both grafts occl.	LAD-LCx snake	10/12	3	
16	49	LAD graft	2/52	4	Graft occl.	LAD graft	30/12	3	Reinvestigation: graft occl.
17	38	RCA LAD LCx grafts	1/12	3	RCA and LCx grafts occl.	PDA LCx grafts	10/12	2	Reinvestigation: poor run-off from new grafts
18 (F)	45	RCA LCx grafts	6/12	3	New stenosis LAD	LAD graft	12/12	0	Perioperative anterior infarct
19	43	LAD graft	1/52	3	Old first LCx stenosis and third LCx occl.	3LCx graft and end.	6/12	2	1LCx not grafted; reinvestigation: 3LCx occl. distal to graft
20	52	LAD graft	10/12	3	New stenosis RCA and PDA	RCA graft	29/12	1	
21	40	LAD graft	3/12	3	Old RCA and LCx stenosis	RCA graft	63/12	1	LCx not grafted
22	49	LAD LCx grafts	42/12	2	Progression RCA stenosis	PDA graft	9/12	0	LAD graft accidentally divided; anterior infarct grade 2 dyspnoea

Table 1—continued

Case no.	Age (y)	First operation	Recurrent Time	AP Grade	Cause of recurrence	Second operation	Follow-up	Angina grade	Comments
23	50	LAD PDA grafts	2/12	3	PDA graft occl.; old stenoses AVCx and LCx	AVCx graft and end.	39/12	2	Reinvestigation: poor run-off from Cx graft
24	42	LAD IM graft LCx graft	24/12	2	New stenosis RCA; stenosis distal to LCx graft; old stenosis 3LCx	RCA graft and end.	35/12	1	Unable to regraft 1LCx or find 3LCx; reinvestigation: poor run-off LCx and RCA grafts
25	57	LAD diagonal grafts; LAD diagonal end.	12/12	4	Diagonal graft occl.; progressive stenosis RCA and Cx	PDA and AVCx grafts	22/12	0	EF 35% before second operation
26	56	LAD graft	7/12	3	LAD graft occl.; old LCx stenosis	LCx graft	30/12	0	LV aneurysmectomy at second op.
27	34	LAD graft	4/12	3	LAD graft occl.; progressive stenosis RCA and LCx	PDA and LCx grafts	43/12	0	LAD too small to regraft
28	58	LAD graft	3/12	3	Progression RCA and LCx	RCA and LCx grafts	4/52	0	
29	54	LAD LCx grafts	54/12	2	LAD graft occl.; new RCA occl.	RCA graft	4/52	0	New inferior akinesia since first op.; unable to regraft LAD
30	58	LAD LCx grafts LAD end.	4/12	4	LCx graft occl.; old 2LCx stenosis	1LCx and 2LCx grafts	4/52	0	
31	60	LAD and PDA grafts	1/52	3	LAD graft occl.; ungrafted LCx	LAD LCx grafts, LAD LCx end.	24/12	2	Low flow LAD graft first op.
32	57	RCA LCx grafts	42/12	2	Both grafts occl.; progression LAD	RCA LCx LAD grafts	7/12	0	
33	53	RCA LAD grafts	1/52	4	LAD graft occl.; ungrafted LCx PDA	LCx PDA LAD grafts	43/12	1	
34	57	1LCx graft	30/12	3	LCx graft occl.; ungrafted LAD and 2LCx	LAD 2LCx grafts, 2LCx end.	25/12	0	
35 (F)	53	LAD LCx grafts	18/12	2	LCx graft occl.; progression RCA	RCA graft; re-implant LCx graft	12/12	0	LBBS
36	44	LAD graft	1/52	4	LAD graft occl.; ungrafted LCx RCA	PDA LAD grafts, PDA LAD end.	—	—	EF 25% before second op.; died postop.; LCx not grafted
37	48	RCA LAD grafts	42/12	4	LAD graft occl.; progression LCx	LAD LCx grafts	12/12	0	EF 40% before second op.; new apical akinesia
38	44	PDA LCx grafts LV aneurysmectomy	8/12	2	LCx graft occl.; progression LCx and diagonal	1LCx 2LCx diagonal grafts	21/12	4	Reinvestigation: all grafts patent
39	55	1LCx 2LCx LAD grafts	3/12	4	Cx grafts occl.; LAD graft stenosis; new RCA stenosis	RCA 1LCx grafts	4/52	0	LAD not regrafted
40 (F)	57	LAD RCA grafts	1/12	4	RCA graft occl.; ungrafted LCx	PDA-inf LV snake LCx graft	4/52	0	

Abbreviations: LMCA, left main coronary artery; RCA, right coronary artery; PDA, posterior descending coronary artery; Inf. LV, left ventricular branch of RCA (not PDA); MCx, main circumflex artery; AVCx, atrioventricular branch of circumflex artery; LCx, lateral circumflex artery (numbered 1 to 3); end., endarterectomy; occl., occluded; IM, internal mammary graft; LV, left ventricular; EF, ejection fraction. All patients male except when specified (F).

Table 2 Late results of each type of operative procedure

	Symptom free	Mild angina	Severe angina	Total
Re-do SVG	5	4	8	17
New SVG	4	3	2	10*
Combined procedure	4	1	2	7

* One patient in this group had grade 2 dyspnoea. SVG, saphenous vein graft.

second attempt. Such factors were identified in surprisingly few cases.

In 1 patient proximal stenosis in a graft seemed to be related to fibrosis at the site of the amputated right atrial appendage, and in 3 the vein was noted to be of poor quality. One patient with a severely diseased distal left anterior descending artery had a low flow down his graft before the chest was closed, but in the others the first grafts seemed to have been executed without difficulty.

By contrast, patients in whom the second procedure included the grafting of previously undisturbed vessels did rather better. Seven out of 10 in whom this was the sole procedure were improved, and in 1 of the failures it is clear that a 'target vessel' was not grafted. Five out of 7 patients who had combined procedures with grafts placed both to previously grafted and to previously ungrafted arteries were improved by the operation and the cause of recurrent pain in 1 of them is obscure because reinvestigation has shown the presence of 4 satisfactory grafts.

Two hundred and nineteen reoperations have been reported from the Cleveland Clinic (Irrarrazaval *et al.*, 1977). Their long-term results are rather better than those reported here, with 65 per cent of patients asymptomatic 2½ years later. These excellent results may be explained in part by the inclusion of 87 patients who had had a previous Vineberg operation so that none of their diseased arteries had been grafted, but this cannot be the complete explanation because the outlook was equally good whether the second procedure was for graft failure, progressive disease, or com-

bined factors. Many of the American patients were referred from other centres and it is possible that the surgeons who carried out the first operation tended to be less experienced than those who did the second, so that there were correctable technical factors in a higher proportion of cases than in the patients described here. The fact that the operative mortality and the incidence of perioperative infarction are similar in both series gives some support for this view.

Our results show that a second aortocoronary bypass operation can be carried out safely. More experience is required before firm guidelines on the indications for reoperation can be drawn, but even at its worst a 50 per cent improvement rate in patients with isolated graft failure may be considered to justify a second attempt in the face of intractable angina and the low operative mortality which can be achieved.

References

- Assad-Morrell, J. L., Frye, R. L., Connolly, D. C., Davis, G. D., Pluth, J. R., Wallace, R. B., Barnhorst, D. A., Eleveback, L. R., and Danielson, G. K. (1975). Aortocoronary artery saphenous vein bypass surgery: clinical and angiographic results. *Mayo Clinic Proceedings*, **50**, 379-386.
- Cooley, D. A., Dawson, J. T., Hallman, G. L., Sandiford, F. M., Wukasch, D. C., Garcia, E., and Hall, R. J. (1973). Aorto-coronary saphenous vein bypass: results in 1492 patients, with particular reference to patients with complicating features. *Annals of Thoracic Surgery*, **16**, 380-390.
- Donaldson, R. M., Honey, M., Sturridge, M. F., Wright, J. E. C., and Balcon, R. (1978). Results of aortocoronary bypass operations. Follow-up in 343 patients. *British Heart Journal*, **40**, 1200-1204.
- Irrarrazaval, M. J., Cosgrove, D. M., Loop, F. D., Ennix, C. L., Jun, Groves, L. K., and Taylor, P. C. (1977). Reoperations for myocardial revascularisation. *Journal of Thoracic and Cardiovascular Surgery*, **73**, 181-188.
- Sandler, H., and Dodge, H. T. (1968). The use of single plane angiograms for the calculation of left ventricular volume in man. *American Heart Journal*, **75**, 325-334.
- Winkle, R. A., Alderman, E. L., Shumway, N. E., and Harrison, D. C. (1975). Results of reoperation for unsuccessful coronary artery bypass surgery. *Circulation*, **51** and **52**, Suppl. I, 61-65.

Requests for reprints to Dr Nicholas Brooks, Cardiac Department, The London Chest Hospital, Bonner Road, London E2 9JX.