Direct myocardial revascularization — 1976

Progress report on the Cleveland Clinic Experience

William C. Sheldon, M.D.

Department of Cardiology

Floyd D. Loop, M.D.

Department of Thoracic and Cardiovascular Surgery

Nearly a decade of experience with graft techniques for coronary artery disease has accumulated since our initial clinical application in May 1967.[1] Since previous attempts at myocardial revascularization were associated with clinical results that were unpredictable and frequently less than completely satisfactory, the early results of bypass graft surgery were also viewed with skepticism. In the past several years, however, there has been increasing agreement that direct myocardial revascularization with bypass graft techniques can result in improvement in symptoms, and improved effort tolerance and myocardial performance under stress. Long-term follow-up studies suggest that bypass graft surgery may improve long-term prognosis,[2,3] inferring that the myocardium is protected against infarction and fatal arrhythmia. Although studies are still in progress, it has been suggested that bypass graft surgery may be of benefit in the more acute ischemic syndromes of unstable angina pectoris and acute myocardial infarction.[4] This report is an update of the Cleveland Clinic Experience.

From May 9, 1967, through December 31, 1975, 10,744 patients underwent various types of graft procedures for coronary artery disease,

with or without associated procedures, at the Cleveland Clinic (*Table 1*). The interposed graft for the right coronary artery was used in fewer than 100 patients, and was rapidly replaced by the bypass technique because of its greater versatility. Although the autologous saphenous vein had been used for grafting purposes in most patients, internal mammary artery (IMA) grafts have been employed with increasing frequency since 1971.[5] Grafts using segments of autologous radial artery, cephalic veins, or prosthetic materials have not been successful in the limited application they have received to date.

During the first few years, selection of patients for bypass graft surgery and the planning of these operations were based upon experiences obtained with earlier revascularization techniques and certain basic assumptions: (a) that more complicated operations would be associated with a higher rate of morbidity and mortality, and (b) that patients with more extensive arteriosclerotic involvement and preexisting myocardial damage would have a higher risk and less potential for rehabilitation. Accordingly, the ideal candidate for bypass graft surgery was the patient with severe segmental stenosis or obstruction of a single coronary artery and normal or nearly normal left ventricular function.[6,7] Although the mortality in the early series was slightly higher, the immediate benefit on symptoms was impressive. The greater versatility of the bypass technique was readily apparent and patients with significant lesions involving the left main coronary artery or its anterior descending branch could now be treated, and multiple bypass grafts could be constructed in patients with more widespread disease without inviting the high complication rate that previously had been anticipated. Improved technical expertise and increasing experience contributed significantly to reducing the hospital mortality from 8.6% to 1.7% in the past 5 years.

The first assumption has been borne out, that more complicated operations are associated with a high mortality, although this has not been prohibitive. The larger proportion of patients have undergone bypass graft procedures in the pure form, in which the hospital mortality has been reduced from 4.8% prior to 1970 to 1.3% in the past 3 years. At the same time, the proportion of patients undergoing multiple graft procedures has increased from 15% to an average of 67% in the past 3 years (*Table 2*).

Table 1. Graft operations for coronary artery disease (Includes other procedures)

Yr	No. of patients	Hospital deaths	%
1967	35	3	8.6
1968	146	8	5.5
1969	366	16	4.4
1970	991	30	3.0
1971	1,484	28	1.9
1972	1,618	24	1.5
1973	1,733	24	1.4
1974	2,139	39	1.8
1975	2,232	38	1.7
Total	10,744	210	2.0

Table 2. Bypass graft for coronary artery disease, 1967–1975 (No associated procedures)

Grafts	No. of patients	Hospital deaths	%
Single	3,309	28	0.8
Double	3,971	51	1.3
Multiple	1,751	46	2.6
Total	9,031	125	1.4

Among patients undergoing bypass grafts combined with various associated cardiac procedures of all types from 1972 through 1975, the hospital mortality was 5.1% when a single graft was utilized, 6.3% for double graft, and 9.7% for three or more grafts plus associated cardiac procedures. The hospital mortality among patients undergoing bypass graft surgery combined with resections of ventricular aneurysm or scar was 3.6% (*Table 3*).

The hospital mortality among patients with normal or nearly normal left ventricular function in the first series of patients operated upon with graft techniques exclusively from 1967 to 1970 was 2.7%, and for patients with moderate hypokinesis it was 3.3%. In a smaller number of patients with severe asynergy, the hospital mortality was 13.3% bearing out the second assumption.

Table 3. Grafts combined with resections of ventricular aneurysm

Yr	No. of patients	Hospital deaths
1972	62	1
1973	72	6
1974	94	1
1975	74	3
Total	302	11 (3.6%)

Perioperative myocardial infarction

The incidence of definite perioperative myocardial infarction, as defined by new Q waves in the electrocardiogram and accompanied by abnormal elevation of the serum glutamic oxaloacetic transaminase (SGOT) was 6.9% among patients undergoing pure graft procedures prior to 1971, compared to 4.2% of patients in the past 4 years (*Table 4*). When correlated with postoperative left ventricular cine angiograms, 29% of patients operated on prior to 1971 who sustained a *definite* perioperative myocardial infarction showed deterioration of left ventricular function by angiography. Among patients who experienced a suspected, but indefinite perioperative infarction, only 8.2% demonstrated angiographic evidence of new or additional left ventricular damage when studied postoperatively.

Other perioperative complications include atrial arrhythmias, which occur in approximately 17% of patients, and have not been associated with mortality, perioperative infarction, graft occlusion, or diminished potential for rehabilitation. Ventricular tachyarrhythmias occur in approximately 1% of patients and also do not portend perioperative mortality, infarction, or graft occlusion. Reoperations, usually for persistent bleeding in the early convalescent phase, have been required in 7% to 9% of patients, also without affecting long-term results.

Postoperative angiographic studies

From 1967 through 1975, 3,849 postoperative arteriographic studies have been performed on patients that were operated upon with graft techniques (*Table 5*). Many of these studies have been performed in cardiac laboratories of other institutions. The interval between surgery and the postoperative study has ranged from 1 month to more than 7 years with a median of approximately 16 months. Many patients have undergone several postoperative studies. Of all grafts that were studied through 1975, 84.2% were patent. Patency is somewhat higher for grafts to the anterior descending artery (88.3%) than for grafts to the right and circumflex

Table 4. Clinically diagnosed perioperative myocardial infarction; pure graft operation

Yr*	No. of patients operated	Infarctions			
		Definite		Suspected	
		No.	%	No.	%
1967–1970	741	51	6.9	43	5.8
1972	1,449	51	3.5	22	1.5
1973	1,601	74	4.6	20	1.2
1974	1,957	92	4.7	21	1.0
1975	2,077	82	3.9	17	0.8
Total (1972–1975)	7,084	299	4.2	80	1.1

* 1971 data incomplete

Table 5. Bypass graft surgery for coronary artery disease; postoperative results, 1967–1975*

Artery	No. grafts	No. patent	No. occluded	% patent
Right	2,105	1,684	421	80.0
Anterior descending	2,926	2,583	343	88.3
Circumflex	1,365	1,118	247	81.9
Total	6,396	5,385	1,011	84.2

* Postoperative studies, 3,849; average interval, 16 months postoperative.
Venous and IMA grafts.
Patients with one or more patent grafts, 90.5%.

arteries (80% and 81.9%, respectively).

The IMA graft, with its higher incidence of patency, has contributed significantly to the results for anterior descending grafts in the past 3 years.[5,8] Through 1975, 812 *in situ* IMA grafts have been studied postoperatively of which 96.4% were patent.

Of all patients studied arteriographically through 1975, 90.5% had at least one patent graft. Among those patients who had multiple grafts constructed, 96.6% had at least one patent graft at the time of their postoperative study.

Studies of the relationship between graft patency and the interval between surgery and the postoperative arteriogram have suggested that the greater proportion of graft failures occur within the first 12 months after surgery (*Table 6*). It should be remembered that all postoperative angiographic results are weighted by a variety of factors, not the least of which is the reluctance of patients who are doing well to submit to a postoperative angiogram, and the greater tendency is for patients with continued or recurrent symptoms to return for such a study. This tendency is reflected in the slightly lower patency rate observed for studies performed within the first 6 months following surgery. Although most graft failures occur early, it is not anticipated that all grafts surviving this period will remain patent indefinitely. Several instances of late graft failure have been documented, and are usually attributable to progression of the atherosclerotic process in

the distal segment of grafted arteries with retrograde thrombotic propagation.

Intraoperative bypass graft flow measurements are frequently obtained to check on surgical technique and to assess the ultimate potential for graft patency. Our studies to date have not suggested a significant correlation between intraoperative flow measurements and subsequent graft patency except at very low flow rates of less than 20 ml per minute (*Table 7*). With flow rates in excess of 20 ml per minute, graft patency has ranged between 85% and 90%.

Although grossly abnormal veins are not selected for graft purposes, a number of specimens of vein grafts taken at the time of surgery have shown histologic evidence of phlebosclerosis. This has not been associated with any increased incidence of graft occlusion, stenosis, or irregularity (*Table 8*).[9]

The relationship between graft patency and the severity of the preoperative lesion has been studied to test the hypothesis that competitive flow through a graft to an artery containing only mild to moderate stenosis would lead to diminished flow velocity as well as to minute volume, sludging, and thrombosis of either the graft or the grafted artery. Very few grafts have been constructed to arteries that contained a lesion of 50% or less; however, the patency among such grafts is 72.8% compared to 85.8% in grafts constructed to arteries containing lesions ranging between 51% and 100%. There is no difference in patency of grafts constructed to arteries that preoperatively contained lesions of 51% to 75%, compared with 76% to 100% (*Table 9*).

The effect of graft surgery on progression of atherosclerosis in arteries treated with bypass grafts was examined in patients operated on from 1967 through 1970, and who have had one or more postoperative studies. Patients with coronary arteries that were totally obstructed preoperatively were excluded from this analysis. Nonobstructed coronary arteries were selected for bypass grafts be-

Table 6. Interval between operation and postoperative angiogram*

Grafts	<7 mo	7–12 mo	13–24 mo	25–36 mo	27–48 mo	>48 mo
No. studied	337	1,359	1,610	222	58	65
No. occluded	64	193	238	31	20	12
Percent patent	81.0	85.8	85.2	86.0	65.5	81.5

* 1972–1974.

Table 7. Graft patency vs. intraoperative flow rate

Flow (ml/min)	No. grafts	No. patent grafts	No. occluded grafts	% patent
0–20	46	32	14	69.6
21–40	142	121	21	85.2
41–60	177	161	16	91.0
61–80	117	105	12	89.7
81–100	60	51	9	85.0
>100	88	81	7	92.0
Total	630	551	79	87.5

cause of significant stenotic lesions in excess of 75% in most instances. At the time of the postoperative study, 33% of the grafted arteries had become completely obstructed (*Table 10*). The potential for new occlusion of a previously patent artery treated with a bypass graft appears to be related more to the severity of the preoperative lesion than to the presence of a graft. Eighty-three percent of new occlusion occurred in arteries containing preoperative stenosis greater than 80%. As demonstrated arteriographically, there was an equal distribution of patent and nonpatent grafts to arteries with new postoperative occlusions. In this series of patients, only six ungrafted arteries developed a new total occlusion, and 25 arteries (in 23 patients) demonstrated progression of disease, with the development of a new lesion of 75% or more during the average 16-month interval between the preoperative and postoperative studies.

Table 8. Status of normal and abnormal veins at postoperative study

	Normal veins (496 grafts)		Abnormal veins (144 grafts)	
	No.	%	No.	%
Patent	436	87.9	129	89.6
Graft stenosis	24	4.8	4	2.8
Graft irregularity	3	0.6	2	1.4

Effect of bypass graft surgery on symptoms

The majority of patients treated surgically with bypass graft techniques report symptomatic improvement postoperatively, and many are asymptomatic. This cannot be critically evaluated, however, without relating postoperative symptoms to the postoperative arteriogram, and to the completeness of revascularization that was achieved. Regardless of how many grafts may have been constructed, the completeness of the surgical *attempt* cannot be equated to the completeness of revascularization

Table 9. Graft patency vs. severity of preoperative lesion*

Type of graft and artery	Preoperative stenosis (% severity)				
	0–50	51–75	76–79	100	Total
SVG to RCA					
Total no. grafts	18	153	544	444	1,159
Patent grafts	15	120	446	348	929
Percent patent	83.3	78.4	82.0	78.4	80.2
SVG to LAD					
Total no. grafts	22	155	759	272	1,208
Patent grafts	15	134	646	247	1,042
Percent patent	68.2	86.5	85.1	90.8	86.3
LIMA to LAD					
Total no. grafts	1	66	386	191	644
No. patent grafts	1	62	366	188	617
Percent patent	100	93.9	94.8	98.4	95.8
SVG to LCX					
Total no. grafts	18	183	599	230	1,030
Patent grafts	12	155	508	196	871
Percent patent	66.7	84.7	84.8	85.2	84.6

* Postoperative angiograms, January 1972 to October 1975.

that was accomplished. In the series of 741 patients treated with pure bypass graft operations from 1967 through 1970, 476 underwent postoperative study permitting an analysis of symptoms and the completeness of revascularization that was accomplished (*Fig. 1*).[3] Ninety-five percent of these patients were symptomatic, with varying degrees of disability preoperatively. Complete revascularization was achieved in more than half these patients, of whom 87% were asymptomatic at the time of their postoperative study. Among patients who achieved partial revascularization, 56% were asymptomatic at the time of their postoperative study, and 33% had only mild disability (Class II symptoms). Most of those who remained symptomatic were aware of clearly improved effort tolerance. In patients for whom no revascularization was accomplished, the majority remained symptomatic (58.2%). The group of patients who did not benefit from surgery and were asymptomatic included patients who sustained a perioperative myocardial infarction, patients whose limited activities prevented the recognition of symptoms, and possibly patients who experienced a placebo effect from the operation. A positive

Table 10. New occlusions of the grafted arteries according to status of graft*

Artery Status of graft	Grafts No.	New artery occlusions No.	%
Right			
Patent	221	80	36.2
Occluded	65	21	32.3
LAD			
Patent	232	69	29.7
Occluded	54	23	42.6
Left Cx			
Patent	92	29	31.5
Occluded	30	5	16.7
Total			
Patent	545	178	32.7
Occluded	149	49	32.9

* Postoperative angiograms through May 1974.

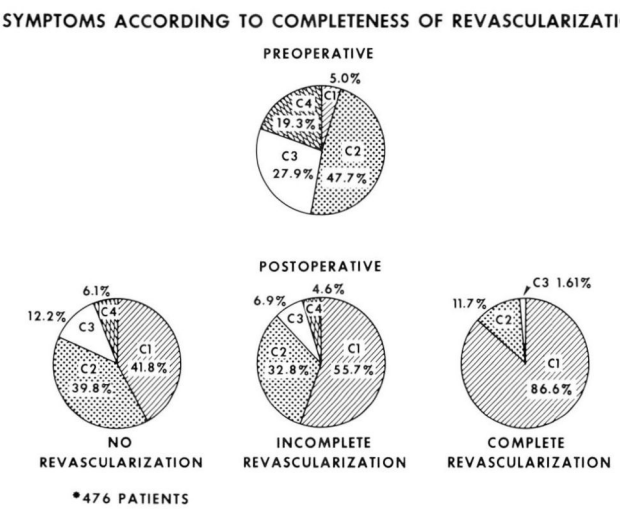

Fig. 1. Preoperative and postoperative distribution of symptoms of 476 patients who had preoperative and postoperative arteriographic studies. Postoperative symptoms are classified according to the completeness of revascularization. (Reproduced by permission of Sheldon WC, et al: Surgical treatment of coronary artery disease: pure graft operations, with a study of 741 patients followed 3–7 yr. Prog Cardiovasc Dis 18: 237–253, 1975.)

correlation between completeness of revascularization and reversal of exercise induced angina or ischemic S-T segment deviations or both in bicycle ergometric stress tests has been observed.[10] In this study, nearly all patients who had exercise induced angina or ischemic S-T segment changes during bicycle ergometric stress testing and who achieved complete myocardial revascularization were relieved of these manifestations of ischemia when stressed postoperatively. Partial revascularization, or occlusion of one or more of the grafts (but not all), were associated with a lower incidence of reversal of stress induced angina or ischemic S-T changes or both, whereas no revascularization resulted in persistence of stress induced angina or ischemic S-T segment changes or both in each of the three patients studied for whom the operation was totally unsuccessful. Other studies have shown improvement in maximal physical work capacity, and in anginal threshold (maximal heart rate times maximal systolic blood pressure) following bypass graft surgery.[11]

Survival following bypass graft surgery

The effect of bypass graft surgery on survival has been studied in 741 consecutive patients who underwent bypass graft surgery in the pure form (with no associated procedures) from May 1967 through December 1970.[3] The hospital mortality in this group of patients was 3%. Follow-up of all patients was a minimum of 30 months, and for 44 patients was at least 6 years. The survival at 24 months was 93.7%, and at 60 months, 83%. Although there is a clear relationship between survival and the extent of coronary disease among medically treated patients, this is less evident in the surgical series. For surgical patients with single vessel involvement, the hospital mortality was 2%, and the 24- and 60-month survival rates were 95.5% and 85.5%, respectively. For patients with double vessel involvement, the hospital mortality was 4%, and the 24- and 60-month survival rates were 91.6% and 78.9%, respectively. For surgical patients with triple vessel involvement, the hospital mortality was 5%, and the 24-month survival was 91.4% (follow-up of 60 months for only eight patients with triple vessel involvement precluded meaningful comparison with other groups).

Although most patients in this series had no more than mild impairment of left ventricular function, reflecting the conservative criteria for selection of patients during these years, 15% of patients did have moderate to severe left ventricular dysfunction. The hospital mortality for patients with normal or mild left ventricular dysfunction was 2.7%, 3.3% for patients with moderate dysfunction, and 13.3% for those with severe left ventricular impairment. The 3-year survival was 93.6% for patients with normal or only mild focal hypokinesia, 89.5% and 71.4% for patients with moderate and severe impairment, respectively.

For purposes of comparison, an ideal group would consist of patients who were studied during the same 1967–1970 time frame who fulfilled the criteria used at that time for surgical treatment, but were randomly assigned medical treatment, with medical treatment controlled and identical

in both groups of patients. Such a control group is not available. As an alternative, we have elected to compare patients treated with bypass graft surgery with a group of patients who were studied at the Cleveland Clinic between 1960 and 1965, and who fulfilled the anatomic criteria on the basis of which the surgical group was selected, and were not operated on.[12] Bypass graft surgery did not become available until 1967, and fewer than 350 patients who were studied between 1960 and 1965 were selected for treatment with those surgical techniques that were available at that time, mainly IMA implantation for anterior descending artery disease. These patients were selected on the basis of having segmental coronary lesions in excess of 75% to 80%, preserved myocardial integrity with normal or nearly normal left ventricular function, and arteries that were of sufficient size and free from distal involvement to permit adequate "run-off". Of 526 patients who fulfilled these criteria, follow-up for 469 was 72 months or longer. Except for the exclusion of patients with moderate and severe left ventricular dysfunction, this group of patients was similar to the surgical group. There was a clear differentiation of survival curves in patients from the medical group according to the presence of single, double, or triple vessel involvement. The average attrition rate for the entire medical group during the first 5 years of follow-up was 8.8% per year, compared to 3.3% per year for the composite surgical group (*Fig. 2*). In the medically treated group, the average annual attrition

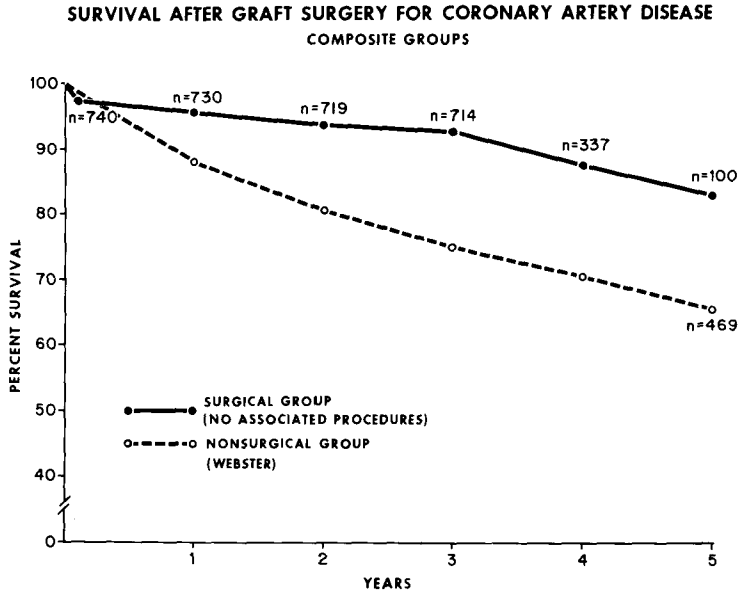

Fig. 2. Survival curves for composite medically and surgically treated groups of patients. The surgical curve includes hospital mortality (3%); all patients had a 30-month follow-up, smaller numbers thereafter. Survival of the medical group dates from the time of arteriographic study; follow-up for the entire group was more than 5 years. (Reproduced by permission of Sheldon WC, et al: Surgical treatment of coronary artery disease: pure graft operations, with a study of 741 patients followed 3–7 yr. Prog Cardiovasc Dis 18: 237–253, 1975.)

rate for patients with single vessel involvement was 3.4% per year, a survival curve closely paralleling that for all surgical groups. The average annual mortality rate of surgically treated patients with single vessel disease was 2.4% per year (*Fig. 3*).

Medically treated patients with double vessel involvement suffered an average annual attrition rate of 9.8% per year, compared to 4.6% per year for surgical patients with double vessel involvement. Medically treated patients with triple vessel involvement experienced a 19.3% per year attrition rate during the first 3 years of follow-up, compared to 4.6% per year in the surgical group.

Survival did not appear to be appreciably benefited by surgical treatment in patients with single vessel disease, except for those in whom the anterior descending artery was involved. Medically treated patients with isolated involvement of the anterior descending artery had an average annual attrition rate of 4.8% per year, compared to 1.7% per year with surgical treatment (*Fig. 4*). In more recent experience,[8] notably with the

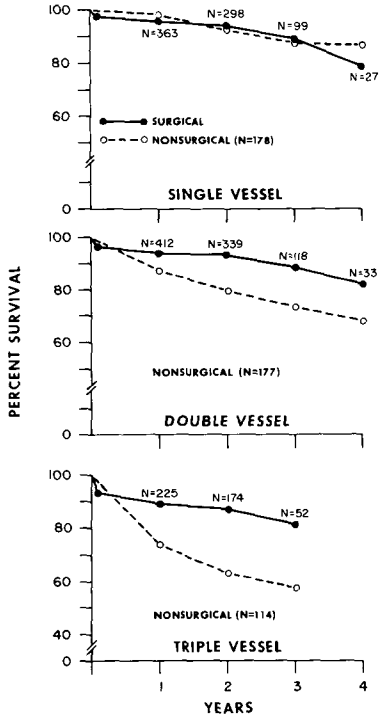

Fig. 3. Survival of medically and surgically treated groups; the patients according to the extent of their coronary disease at the time of the initial arteriographic study. The number of grafts constructed did not equal the number of vessels involved in all instances. (Reproduced by permission of Sheldon WC, et al: Surgical treatment of coronary artery disease: pure graft operations, with a study of 741 patients followed 3–7 yr. Prog Cardiovasc Dis 18: 237–253, 1975.)

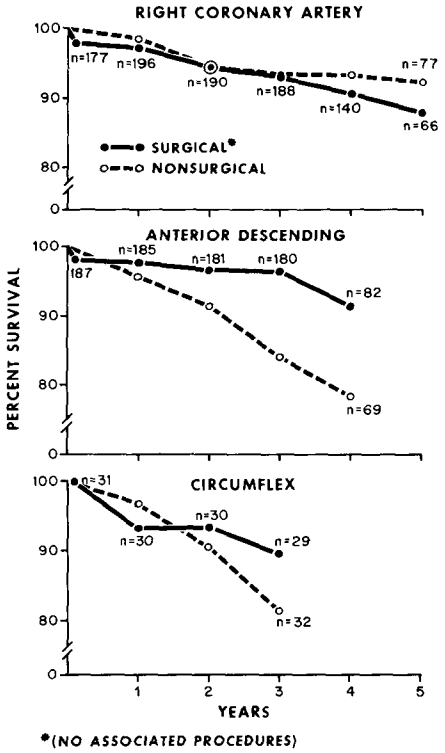

Fig. 4. Survival curves for patients with single vessel involvement, according to the specific artery involved. See text for details. (Reproduced by permission of Sheldon WC, et al: Surgical treatment of coronary artery disease: pure graft operations, with a study of 741 patients followed 3–7 yr. Prog Cardiovasc Dis 18: 237–253, 1975.)

IMA graft, survival of surgically treated patients with single vessel involvement appears to be better than that for the earlier series.

Indications for bypass graft surgery in coronary artery disease

At best, direct myocardial revascularization with bypass graft techniques is palliative, and cannot be expected to retard or arrest the atherosclerotic process. When coronary arteriography demonstrates a significant myocardial perfusion deficit, imposing a risk of myocardial infarction or disability from symptoms of myocardial ischemia, surgical treatment may be considered. Therefore, patients are selected for surgery on the basis of either disability from angina pectoris or jeopardized myocardium. The ultimate objective of bypass graft surgery is for functional rehabilitation and prolongation of life.

Patients are not accepted for surgery who have early or mild forms of coronary atherosclerosis that do not impose an immediate threat to their functional capacity or risk of myocardial infarction or death. Patients who have already sustained extensive myocardial damage and suffer more from the effects of myocardial incompetence rather than myocardial ischemia have little to gain from revascularization surgery. Patients with significant disability from angina pectoris may anticipate benefit from bypass graft surgery, especially if complete revascularization is possible, in which case complete relief from symptoms may be achieved. Improved effort performance can be anticipated for most patients for whom partial revascularization can be accomplished. Patients with more extensive disease, that is double or triple vessel involvement, have more severe symptoms and a poorer prognosis, and therefore have the most to gain from bypass graft surgery.

Asymptomatic patients are not frequently referred for coronary arteriography. At the time of arteriographic study, some patients are asymptomatic by virtue of having restricted their activities, or they may have had previous symptoms or myocardial infarction. If their arteriograms demonstrate a significant perfusion deficit with double or triple vessel involvement or jeopardized myocardium, consideration for surgical treatment should not necessarily be precluded by the absence of symptoms, for prognosis is better related to anatomy than to symptoms. If a patient has a totally obstructed artery that is adequately collateralized from other sources and he has no myocardial damage or symptoms of myocardial ischemia, he would appear to have little need for surgical treatment. If such a patient is symptomatic, he could benefit from surgery. A patient with a severe segmental stenosis of the major artery *without* evident collateral protection has a more uncertain prognosis; he has a risk of infarction and its attendant complications, and revascularization surgery may significantly reduce these risks. Therefore, the selection of patients for surgical treatment is based not only upon symptoms, but upon the anatomy and the assessment of the risks to myocardium and to life imposed by the arteriosclerotic disease, and the potential for improvement with surgical treatment.

Summary and conclusion

The advent of bypass graft surgery for coronary artery disease has stimulated intensive study of the patho-

physiology of coronary heart disease and its natural history in the past 9 years. Few therapeutic interventions have commanded such widespread interest or intensive study. The evidence to date suggests that bypass graft surgery can be applied to selected patients with a low risk, and with a potential for improvement in symptoms as well as survival. Only existing lesions can be treated, and the future course of the disease cannot be anticipated. Atherosclerotic progression is the factor limiting the ultimate benefit from these therapeutic modalities. It is anticipated that the next decade will witness new techniques for bypass graft surgery, further refinement of its indications, and a better understanding of the nature and pathophysiology of coronary atherosclerosis.

References

1. Favaloro RG: Saphenous vein autograft replacement of severe segmental coronary artery occlusion: operative technique. Ann Thorac Surg **5:** 334–339, 1968.
2. Sheldon WC, Rincon G, Effler DB, et al: Vein graft surgery for coronary artery disease. Survival and angiographic results in 1,000 patients. Circulation **48:** Suppl **3:** 184–189, 1973.
3. Sheldon WC, Rincon G, Pichard AD, et al: Surgical treatment of coronary artery disease: pure graft operations with a study of 741 patients followed three to seven years. Prog Cardiovasc Dis **18:** 237–253, 1975.
4. Cheanvechai C, Effler DB, Loop FD, et al: Aortocoronary artery graft during early and late phases of acute myocardial infarction. Ann Thorac Surg **16:** 249–260, 1973.
5. Loop FD, Effler DB, Spampinato N, et al: Myocardial revascularization by internal mammary artery grafts; a technique without optical assistance. J Thorac Cardiovasc Surg **63:** 674–680, 1972.
6. Sheldon WC, Sones FM Jr, Shirey EK, et al: Reconstructive coronary artery surgery: postoperative assessment. Circulation **39:** Suppl **1:** 61–66, 1969.
7. Shirey EK: Selection of the surgical candidate. Surg Clin North Am **51:** 1023–1033, 1971.
8. Loop FD, Irarrazaval MJ, Bredee JJ, et al: Internal mammary artery graft for ischemic heart disease. The effect of revascularization on survival. Submitted to N Engl J Med.
9. Cheanvechai C, Effler DB, Hooper JR, et al: The structural study of the saphenous vein. Ann Thorac Surg **20:** 636–645, 1975.
10. Siegel W, Lim JS, Proudfit WL, et al: The spectrum of exercise test and angiographic correlations in myocardial revascularization surgery. Circulation **51–52:** Suppl **1:** 156–162, 1975.
11. Siegel W, Lim JS, Proudfit WL, et al: Exercise test and angiographic correlations in myocardial revascularization surgery. (Abstr) Circulation **49–50:** Suppl **3:** 132, 1974.
12. Webster JS, Moberg C, Rincon G: Natural history of severe proximal coronary artery disease as documented by coronary cineangiography. Am J Cardiol **33:** 195–200, 1974.