Myocardial revascularization at The Cleveland Clinic Foundation—1981

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The 1981 surgical experience in 2616 consecutive isolated bypass patients is reviewed. Median age of these patients continues to rise, reaching 59 years in 1981 (23% were >65 years and 8% >70 years); 15% were women. Multivessel coronary atherosclerosis occurred in 92% (two-vessel disease in 24% and three-vessel disease in 69%). Left main artery lesions have plateaued at 12% of surgical patients. Abnormal left ventricular contraction was documented in 55%. Operative (hospital) mortality was 0.8%. Major morbidity included perioperative myocardial infarction (principally new Q-waves) in 1.4% and neurologic deficit in 1.7%. Intra-aortic balloon pump usage was 0.9% and 0.8 unit of blood was used per patient; prevalence of internal mammary artery graft usage was 49%; and complete revascularization was achieved in 82%.

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Fifteen years have passed since the inception of coronary artery bypass surgery at The Cleveland Clinic Foundation in 1967. Within the next decade, this controversial procedure gained popularity and became the most frequently performed cardiac operation. In 1980, 140,000 coronary artery operations were performed in the United States. Advances in myocardial protection, more complete revascularization, reduced blood usage, and improved perioperative management highlight surgical progress. Major morbidity has decreased significantly when the early years are compared with recent experience.[1] Hospital mortality has been reduced to 2% or less in many institutions. This report reviews our 1981 experience with isolated coronary bypass operations.

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Methods

Between January and December 1981, 2616 patients underwent direct myocardial revascularization in The Cleveland Clinic Foundation. Data on these consecutive patients were obtained from the Cardiovascular Information Registry and include emergency, elective, and reoperative procedures. The series is limited to "pure" cases, as patients who underwent bypass grafting combined with ventricular aneurysmectomy, carotid endarterectomy, and valve repair or replacement are excluded.

Clinical characteristics

Of the 2616 patients, 2225 (85%) were men and 391 (15%) were women. The number of women undergoing myocardial revascularization has increased steadily from the 10% operated on in 1971. The median age increased from 58 years in 1980 to 59 years in 1981. In 1981, 22.6% of the surgical patients were aged 65 years or more compared to 18.5% of patients operated on in 1980; 7.8% of the patients were 70 or more compared with 6.3% in 1980.

In this 1981 series, 609 patients (23.2%) were asymptomatic or had mild symptoms, 1531 (58.6%) had moderate angina, and 476 (18.2%) had severe or unstable angina.

The incidence of electrocardiographically documented preoperative myocardial infarction increased slightly in 1981; 32.0% (836 patients) compared with 30.3% in 1980. Other risk factors have remained relatively constant. Diabetes requiring insulin was present before surgery in 242 patients (9.3%). Hypertension on admission (>140 mm Hg systolic and >90 mm Hg diastolic) was documented in 181 patients (6.9%). Hypercholesterolemia (>250 mg/100 ml) was found in 1230 (47.5%), and hypertriglyceridemia (>140 mg/100 ml) occurred in 1271 (64.4%).

Angiographic characteristics

The extent of disease continues to change among patients undergoing myocardial revascularization (*Table 1*). Vessels stenosed more than an estimated 50% constituted severe coronary atherosclerosis. The prevalence of one-vessel disease declined to 7.6% (198) in 1981 from 9.0% in 1980. Multivessel disease occurred in 92.4% of the 1981 series [including two-vessel disease in 620 patients (23.7%) and three-vessel involvement in 1798 (68.7%)]. The incidence of severe narrowing of the left main coronary artery has plateaued at 12% for the past five years.

Table 1. Angiographic characteristics

Subset	Number of patients	Percent
One-vessel disease	198	7.6
Two-vessel disease	620	23.7
Three-vessel disease	1798	68.7
Left main	311	11.9
Normal left ventricle	1168	44.6
Abnormal left ventricle	1448	55.4

Table 2. Morbidity after myocardial revascularization, 1981 (n = 2616)

	Number of patients	Percent
Reoperation for bleeding	63	2.4
Stroke	45	1.7
Low cardiac output	35	1.3
Myocardial infarction	37	1.4
Renal failure	16	0.6
Respiratory insufficiency	41	1.6
Wound complications	14	0.5
Gastrointestinal bleeding	5	0.2

Left ventricular impairment was present in more than half of the patients operated on in 1981 (*Table 1*). Among all patients, 1168 (44.6%) demonstrated normal left ventricular function; 794 patients (30.4%) had mild (one of five segments) impairment of contractility; 430 (16.4%) had moderate (2–3 segments) impairment; and 224 (8.6%) had severe (diffuse) impairment.

Results

Of these 2616 myocardial revascularization procedures, 59% of the patients received three or more grafts, and only 10% underwent a single bypass procedure. The average number of grafts per patient was 2.7 compared with 2.6 in 1980. The internal mammary artery has been used with increasing frequency in recent years: 1271 of 2616 patients (48.6%) in 1981 compared with 33.1% in 1980 and 34.5% in 1979. Complete revascularization was achieved in 2131 patients (81.5%) as compared with 80% in 1979 and 1980.

Morbidity in coronary artery surgery has not changed significantly since 1980, although some aspects continue to improve (*Table 2*). Perioperative myocardial infarction (new Q waves) occurred in 37 patients (1.4%); this incidence has not changed from 1979 (1.4%) or from 1980 (1.3%). The incidence of reoperation for bleeding in 1981 was 2.4%, whereas in 1980 it was 3.4%. A blood conservation program,[2] established in 1976, achieved its best results in 1981. The use of bank blood has been further reduced to 0.8 unit per patient from 1.1 in 1980. Seventy percent of patients undergoing primary myocardial revascularization received no blood or blood products in the intraoperative or postoperative period.

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Table 3. Causes of death following myocardial revascularization

Ischemia/infarction	12 (52%)
Cerebrovascular accident	8 (35%)
Sudden death	1 (4%)
Mediastinitis	1 (4%)
Respiratory and renal failure	1 (4%)

Table 4. Operative mortality by angiographic variables

Subset	Number of patients	Operative mortality
One-vessel disease	198	1 (0.5%)
Two-vessel disease	620	3 (0.5%)
Three-vessel disease	1798	19 (1.1%)
Normal LV	1168	8 (0.7%)
Mild, moderate, or severe LV impairment	1448	15 (1.0%)

LV = left ventricle.

Mortality for this series of patients undergoing pure myocardial revascularization in 1981 was 0.9% (23 patients). Mortality for men was 17 of 2225 (0.8%) and for women, 6 of 391 (1.5%). Of those receiving IMA grafts, one patient died while undergoing this procedure as a reoperation. Of the 23 deaths, 12 were of myocardial failure associated with ischemia, myocardial infarction, or low cardiac output in the immediate postoperative period (*Table 3*). Cerebrovascular accident was the second major cause of death (8 patients). One died suddenly on a regular nursing floor five days after undergoing a single sequential graft to both branches of the right coronary artery. One patient died of mediastinitis 45 days after operation. There was one death from renal failure. Of the 23 patients who died, 17 had undergone a primary procedure (0.7% mortality among primary operations), and 6 had had coronary artery reoperations (3.3% mortality among reoperations). Operative mortality by angiographic variables is shown in *Table 4*.

The use of the intra-aortic ballon pump continues to decrease, from 3.4% of patients (80/2379) in 1979 to 2.1% (52/2443) in 1980, to 0.9% (23/2616) in 1981. Ten insertions were in reoperation patients; 13 were in primary revascularization patients.

Discussion

Operative risk in coronary artery surgery has been the subject of comprehensive analyses. The 1975–1978 Coronary Artery Surgery Study (CASS) evaluated numerous clinical and angiographic variables by univariate analysis for their effect on operative mortality.[3] Variables that contained the most predictive information were subjected to discriminant analysis. Age above 70 years, >90% left main coronary artery obstruction, and female sex were the three most important operative risk factors in coronary artery surgery. Gender was a stronger descriptor of operative risk than left ventricular impairment. In our experience, emergency operation and congestive heart failure are equally strong indicators of risk. Although left main coronary artery disease figures prominently in risk analyses, operative mortality in this subset is declining, as shown by the 1% mortality in this 1981 experience.

Improving results cannot be attributed to selection of easier cases. The median age continues to rise from 50 years in the 1967–1970 experience to 59 years in 1981. Nearly one quarter of the patients are more than 65 years of age and nearly 10% of our surgical population are 70 years or older. Selection is no longer based solely on disabling symptoms. Consideration for myocardial revascularization is probably related more to an estimation of myocardial jeopardy as shown by the severity and location of major arterial obstruction. Other criteria include the presence of left main stenosis, change in anginal pattern and the patient's own dissatisfaction with limitations in lifestyle.[4]

The prevalence of three-vessel disease, which includes almost all of the patients with left main stenosis, reached 69% in the 1981 experience. Slightly more than half of the patients have abnormal left ventricular contraction, a percentage which has changed little from previous years. Surgeons continue to perform more bypass grafts per patient, which increased from a mean of 2.7 in 1981 compared with 2.6 in 1980, 2.2 in 1975, and 1.5 in 1967–1970. The so-called moderate lesion (estimated 40% to 50% narrowing) is now routinely bypassed in conjunction with grafts to more severely obstructed vessels.[5] In 1981, 81% of the patients received bypass grafts to all major arteries larger than 1 mm and ≥50% obstructed, the generally recognized criteria for complete revascularization.

The amount of bank blood used per patient has been reduced to 0.8 unit, and the incidence of reexploration for bleeding has declined to 2.4%. The occurrence of perioperative myocardial injury (new Q waves) has stabilized at approximately 1%. Hospital mortality has remained slightly higher in women (1.5%), than in men (0.8%). One aspect in which improvements have not been apparent is incidence of perioperative cerebral vascular accident. The incidence of postoperative neurologic injury was 1.7%. This number has ranged from 1% to 2% during the last ten years and approximately half of these episodes are permanent. However, this incidence of neurologic deficit has plateaued despite

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greater age of surgical patients, more extensive coronary atherosclerosis, a greater prevalence of preoperative left ventricular dysfunction, a greater number of grafts performed and an increased number of reoperations. The most frequent causes of death were myocardial failure and cerebral vascular accident. The majority of patients who died belonged to a subgroup of candidates whose risk for surgery was predictably higher.

The number of reoperations for myocardial revascularization continues to increase. In 1981, 7.0% (182 patients) of the total operative volume were reoperations. In 1979, 118 (5.0%) and in 1980, 114 (5.9%) reoperations were performed. The use of the intra-aortic balloon pump is declining and its use in the preoperative period to control unstable angina has been eliminated by better pharmacologic management.

Although present methods of intraoperative and postoperative management have achieved a high degree of safety and reliability that permits their application to patients with a wide range of risk, we believe that continued evolution and refinement of these techniques will occur. It is to be hoped that the wider use of prophylactic surgery to prevent infarction will reduce the need for surgery in high-risk patients with significant myocardial damage.

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