Myocardial revascularization in The Cleveland Clinic Foundation—1979

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Coronary artery surgery has entered the second decade of active clinical practice. Quantitative advances have occurred principally in anesthesia management, myocardial protection, blood conservation, pharmacologic and mechanical support of the circulation, postoperative monitoring, and operative experience. The consequence of this evolution is that myocardial revascularization is performed in both large referral centers and smaller community hospitals with potential for low morbidity and mortality and clear evidence of effective relief of symptoms and extended longevity.

Acceptance of the salutory effects on long-term survival by multiple bypass graft procedures[1] has gained precedence so that debates about effectiveness have given way to careful analysis of late results. The question is not whether the operation is sound; the question is how long will the palliation last? There is good evidence that patients for whom the operation has been successful are well protected for at least the first 5 postoperative years.

Our initial experience in direct myocardial revascularization has been reported[2] and compared with isolated myocardial revascularization procedures divided into 1000 patient cohorts from 1971 through 1978.[3] In contrast to an operative mortality of 3% from 1967 to 1970, hospital mortality de-

clined to 1% in the later experience, and virtually every form of morbidity with the exception of neurologic deficit decreased significantly. Whereas the 5-year survival for the early experience was 89.8% for a group in which 44% had multivessel coronary atherosclerosis, 5-year survival for 1971–1973 cohorts increased to 92.4%, despite the increase in prevalence of multivessel disease to 83%.

A periodic review of each year's experience will be useful as a data base for future discussions and for perspective on the proper role of surgery in therapy for coronary atherosclerosis. The 1979 series analyzed herein is a consecutive series of isolated revascularization cases performed during the calendar year. This report documents the experience from a large referral center and ultimately serves to chronicle trends in mortality and morbidity. To improve results consistently and provide optimum treatment, an institution must have knowledge of practices and results on a yearly basis.

Methods

Clinical, angiographic, and operative variables of each cardiovascular patient are stored in a computer-based registry. This cardiovascular information registry was used to identify the characteristics of each patient who underwent isolated coronary artery surgery from January 1 through December 31, 1979. This series *includes* patients with stable and unstable angina pectoris, patients with normal and severely impaired ventricular function, patients who underwent elective and emergency operations, reoperative bypass operations as well as primary operations, patients with chronic renal failure on hemodialysis, chronic metabolic disease, and patients in all age groups. *Excluded* are patients who underwent coronary bypass surgery combined with valve replacement, ventricular aneurysm resection, or carotid artery surgery. The hospital medical records of all patients who did not survive surgery were reviewed for pertinent information. This report concerns only the in-hospital phase of patient care; post-hospitalization data are not included.

Clinical characteristics

The age range of 1979 patients was from 29 through 79 years. In 2053 men (86.3%) and 326 women (13.7%), the median ages were 56 and 59, respectively. Other clinical and angiographic characteristics are listed in *Table 1.*

Perioperative management

Beta-blockade and nitrates were continued to the day of operation and generally the dosages were not tapered. Anesthesia was induced with attention to electrocardiographic monitoring, radial arterial pressure and either right atrial or pulmonary capillary wedge pressure to ensure a normal rate-pressure product. Myocardial ischemia, hypertension, and tachycardia were treated with propranolol, nitroglycerin or nitroprusside

Table 1. Clinical and angiographic characteristics

	Patients	
	No.	%
Hypertension at admission (diastolic >90 mm Hg)	231	9.7
Diabetes	188	7.9
Cholesterol >250 mg/dl	1051	44.2
Triglycerides >140 mg/dl	1663	69.9
One-vessel disease (narrowing >50%)	231	9.7
Two-vessel disease	621	26.1
Three-vessel disease	1230	51.7
Left main coronary artery	297	12.5
Normal left ventricle	1091	45.9
Abnormal left ventricle	1288	54.1

intravenously and, conversely, hypotension was treated actively. The long saphenous vein was delicately handled and removed through several leg incisions. Overdistention of the vein conduit was assiduously avoided, and the vein was stored in cold, heparinized blood. In previous years bicaval cannulation including a left atrial or left atrioventricular vent had become the standard cannulation procedure. Beginning in 1979 this practice was modified, and for uncomplicated single- or multiple- graft patients, a two-stage single atrial cannula, aortic perfusion line, and aortic vent were used more frequently.

The myocardium was protected in most cases by core cooling and cold potassium cardioplegia. Distal coronary anastomoses were performed under one period of aortic cross-clamping. In 1979, interrupted siliconized 7-0 silk sutures supplanted the 6-0 silk used previously. Proximal vein graft anastomoses to the aorta were performed with a running polypropylene suture. Internal mammary artery-coronary artery anastomoses were done late in sequence. Indwelling left atrial pressure catheters or balloon flotation pulmonary artery catheters were frequently used for early postoperative monitoring. Temporary pacing wires were installed routinely.

A blood conservation protocol established earlier accounted for an estimated saving of 18,000 units of blood in 1979.[4] Fifty-eight percent of the patients in 1979 received no blood or blood products during the operation or in the subsequent hospital course. Important features of this blood conservation program include (1) removal of one or two units of blood through the oxygenator venous lines at the outset of cardiopulmonary bypass; (2) meticulous surgical hemostasis; (3) regionallyheparinized red cell processing system which eliminates the "discard" suction; (4) a nonhemic oxygenator prime and later transfusion of all oxygenator contents; (5) organized and expeditious closure, and (6) transfusion of shed mediastinal blood postoperatively.

Postoperative management was directed toward maintenance of optimal levels of circulating blood volume, blood pressure, cardiac index, and peripheral vascular resistance. Pharmacologic after-load reduction was used liberally and inotropic agents were infrequently administered. Patients with refractory unstable angina preoperatively or those who experienced persistent low cardiac output unresponsive to inotropic-vasodilator combinations were managed with intraaortic balloon counterpulsation coupled with the appropriate pharmacologic treatment. Mechanical ventilation was maintained during the first postoperative night.

Results

During 1979, 2379 isolated myocardial revascularization procedures were performed in The Cleveland Clinic Foundation by seven staff cardiac surgeons. The mean number of grafts per patient was 2.7. The operative or hospital mortality was 1.1% (27 patients). The mortality for men was 0.9% and for women was 2.8%. Of 112 patients 70 years old or older, five died (4.5%). Thirty-five percent (822/2379) of the patients received internal mammary artery grafts with a hospital mortality of 0.2% (two patients). The incidence of coronary artery reoperations increased from a 10-year average of 2.7% of our isolated graft experience to 5.3% in 1979. In these 126 reoperation patients, the hospital mortality was 0.8% (one patient).

The intraaortic balloon pump was used in the management of 80 patients

(3.4%). Seventeen had the balloon pump inserted preoperatively for unresponsive unstable angina and all survived. Of the 54 patients in whom balloon devices were inserted intraoperatively, six died and the remainder survived and were discharged. Balloon support was used in nine patients postoperatively and four died. Two patients could not be weaned from cardiopulmonary bypass even with balloon counterpulsation and required insertion of a temporary left ventricular assist device; one died and the other is a long-term survivor.[5]

Definite perioperative infarction is defined as the appearance of new Q waves and was almost always associated with an abnormal rise of cardiac enzyme levels. Probable infarction is defined as decreased R voltage in two or more leads associated with elevated enzyme levels. As defined above, definite or probable myocardial infarction occurred in 1.8% (43) of the 1979 patients. Postoperative bleeding, which required reoperation for hemostasis, occurred in 3.1% (73) and the mortality rate of patients who underwent exploration for bleeding was 2.8%. The incidence of bleeding in patients who received an internal mammary artery graft was 3.1% (25).

Table 2. Causes of death following myocardial revascularization surgery, 1979

Causes	Number of patients
Sudden death, presumably arrhythmia	7
Ischemia/infarction/low output	6
Gastrointestinal complication	3
Intraoperative complication	2
Cerebrovascular accident	2
Mediastinitis	2
Cardiac rupture from perioperative infarction	1
Pulmonary embolus	1
Cardiac tamponade from pacing wire removal	1
Noncardiac pulmonary edema	1
Presacral soft tissue necrosis	1
Total	27

Analysis of operative mortality

Table 2 classifies the primary cause of death of the 27 patients who died in the operating room or later in hospital. The most frequent cause of death was sudden cardiovascular collapse, which occurred in seven patients an average of 6 days after operation. The causes in two sudden events are known: one patient with preoperative ventricular arrhythmia was unresponsive to verapamil therapy and another died from recurring arrhythmia related to perioperative infarction. The causes of other fatal collapse are not known.

Postoperative low cardiac output syndrome was the primary cause of death in six patients. Of these, four died during the first week following operation with irreversible left ventricular failure, and the other two died at 16 and 84 days with multiple system failure related to inadequate cardiac output. These deaths are attributed to myocardial ischemia or infarction.

Only two patients in the total series died in the operating room. One patient had an acute ascending aortic dissection and died during attempted repair. The other intraoperative death occurred in a man with subtotal obstruction of the left main coronary artery, total occlusion of the right coronary artery and unstable angina, whose anomalous trachea necessitated emergency tracheostomy during anesthesia induction. Massive intraoperative myocardial infarction occurred, and all support measures failed. All other patients were successfully weaned from cardiopulmonary by-

pass and transferred to the postoperative cardiac unit.

Another patient had massive noncardiac pulmonary edema in the operating room, perhaps related to an unidentified allergic reaction. He experienced chronic respiratory distress and ultimately multiple system failure and died on the 25th postoperative day. Postoperative gastrointestinal complications were responsible for three other deaths. These included cecal volvulus and upper gastrointestinal bleeding, perforated diverticulitis with peritonitis, and acute gangrene of the rectum in a chronic hemodialysis patient. Bacterial mediastinitis ultimately led to the deaths of two patients; two others had fatal strokes; and a fifth patient died of sepsis related to a bizarre presacral soft tissue necrosis.

Discussion

Of all patients who underwent isolated bypass graft surgery in 1979, 98.9% survived and were discharged from the hospital. Thirty-five percent of the patients were judged to be in a good-risk category, based on the criteria for selection of the internal mammary artery as a bypass conduit. These patients with chronic stable angina were generally younger than 65 years and did not have evidence of severe left ventricular impairment or hypertrophy. Of the 832 patients in this selected group, 99.8% survived. The need for reoperative coronary surgery did not appear to represent an additional significant factor; the low mortality rate (0.8%) in this group is encouraging in view of the modest increase in need for reoperation mainly due to progressive coronary atherosclerosis, graft failure, or both.

Operative risk factors are apparent in these 1979 patients. Women patients experienced a threefold greater operative mortality than men. In those older than 70, mortality was 4.5% younger in comparison with 1.0% for patients less than 70. The need for reexploration for postoperative bleeding was associated with 2.5 times greater risk of mortality. Unequivocal perioperative myocardial infarction could be attributed to preoperative instability, inadequate intraoperative myocardial protection or both in almost all occurrences.

The intraaortic balloon pump played a major role in this experience. All patients who had balloon counterpulsation for preoperative stabilization survived. Although it is not possible to predict mortality without balloon support, it would be substantially higher than the 15.6% (10/64) that occurred with counterpulsation.

Cardiac failure accounted for 70% of the hospital deaths; approximately a third of the deaths were heralded by sudden cardiovascular collapse. All of the hospital deaths were directly related to the operative procedure. Future improvements in surgical management, perioperative myocardial protection, postoperative vigilance, and the increased use of temporary mechanical ventricular assistance can be expected to reduce further the overall mortality of coronary artery surgery. The ultimate achievable survival rate has not yet been reached.

Summary

A consecutive series of 2379 isolated myocardial revasularization operations performed during the calendar year 1979 is reported. An average of 2.7 bypass grafts per patient was performed and the hospital mortality was 1.1%. Mortality in the selected group of patients who received internal mammary artery grafts was 0.2% and in reoperations, 0.8%. Hospital mortality was re-

lated to the heart and great arteries in 70% of patients. Future improvements in risk are anticipated.

References

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