

# Fatal Myocardial Infarction Following Abdominal Aortic Aneurysm Resection

Three Hundred Forty-Three Patients Followed 6–11 Years Postoperatively

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Routine preoperative coronary angiography has been recommended to all patients scheduled for elective abdominal aortic aneurysm resection at the Cleveland Clinic since 1978. Patients found to have severe, correctable coronary artery disease (CAD) have been advised to undergo myocardial revascularization prior to aneurysm resection in an attempt to reduce the incidence of fatal postoperative myocardial infarction. In order to provide an historic standard with which the results of this approach may eventually be compared, complete follow-up information has been obtained for 96% of 343 consecutive patients who underwent abdominal aortic aneurysm resection between 1969 and 1973. Fatal myocardial infarction accounted for 37% of early postoperative deaths and occurred in 6% of the entire series. Among the patients who survived operation, the five-year mortality rate was 31% and the 11-year mortality rate was 52%. Complications of CAD caused 39% of the deaths that occurred within five years after operation and 41% of the deaths that occurred within 11 years. The late incidence of fatal myocardial infarction among patients who had preoperative evidence of CAD was statistically significant ( $p < 0.05$ ).

CORONARY ARTERY DISEASE (CAD) is the most common cause of early postoperative death and late death following resection of abdominal aortic aneurysms. According to several large published series,<sup>1,4,7,13–15,17</sup> myocardial infarction is responsible for approximately 40% of all deaths among patients who undergo aneurysm resection and occurs with even greater frequency among patients who have preoperative evidence of CAD. Because of the recognized risk of postoperative complications, many patients with suspected CAD have arbitrarily not been considered as candidates for aneurysm resection unless progressive enlargement or the appearance of symptoms indicate that rupture is imminent. Under these circumstances, Szilagyi and associates<sup>13</sup> found that 71% of

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the patients they treated died during observation from either myocardial infarction or aneurysm rupture.

Several reports<sup>2,10,11</sup> suggest that patients who have had previous myocardial revascularization with the use of coronary artery bypass grafts experience fewer cardiac complications after subsequent vascular and other major operations than would be expected even in the absence of known CAD. Since patients who have abdominal aortic aneurysms appear to be at a particularly high risk for both early and late postoperative cardiac complications, routine preoperative coronary angiography has been recommended to all patients scheduled for elective aneurysm resection at the Cleveland Clinic since 1978. As described in a previous report,<sup>6</sup> severe, correctable coronary artery lesions were documented using this format in 56% of the patients with abdominal aortic aneurysms who had preoperative evidence of CAD and in 22% of those with no clinical indication of CAD. Elective myocardial revascularization was performed in 38% of the patients in this investigation, and 51 patients underwent aneurysm resection with a single postoperative death which was caused by a cerebrovascular accident.

Since routine preoperative coronary angiography and, if indicated, staged myocardial revascularization continue to be recommended without prospective randomization to all patients under consideration for elective resection of abdominal aortic aneurysms at this institution, an historic control group will be required to evaluate the influence of this approach on late survival. This report presents such a series consisting of 343 consecutive patients who underwent aneurysm resection between 1969 and 1973. Late follow-up information was obtained by telephone

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TABLE 1. Distribution of 343 Patients According to Indications for Operation and Year

Year	Elective		Symptomatic Intact		Ruptured		Total	
	Number of Patients	Per Cent	Number of Patients	Per Cent	Number of Patients	Per Cent	Number of Patients	Per Cent
1969	51	74	9	13	9	13	69	100
1970	47	66	14	20	10	14	71	100
1971	41	72	9	16	7	12	57	100
1972	49	74	8	12	9	14	66	100
1973	63	79	9	11	8	10	80	100
Total	251	73	49	14	43	13	343	100

contact with each patient, a close surviving family member, or the referring physician and is complete for 96% of the patients.

### Patient Information

The 343 patients in this series consisted of 300 men and 43 women with an age range of 45–89 years (mean: 66 years). Seventy-six patients (22%) were less than 60 years of age at the time of operation, 154 patients (45%) were 60–70 years of age, 100 patients (29%) were 70–80 years of age, and 13 patients (4%) were over 80 years of age.

The indications for operation are given for each year of this study in Table 1. Elective operations were performed for 251 patients (73%) who had asymptomatic aneurysms. Urgent procedures were necessary for 49 patients (14%) who had symptomatic but intact aneurysms associated with acute pain in the back or abdomen suggesting acute aneurysm expansion. Emergency intervention with a minimum of preoperative preparation was required for 43 patients (13%) who had ruptured aneurysms.

### Atherosclerotic Risk Factors

One hundred eighty-one patients (53%) had hypertension under medical treatment or blood pressure measurements greater than 150/90 mmHg. Diabetes mellitus under medical treatment, an abnormal glucose tolerance test, or a fasting or two-hour postprandial blood glucose level greater than 120 mg/dl were present in 66 patients (19%). The serum cholesterol value (range: 75–443 mg/dl) was greater than 270 mg/dl in 164 patients (48%), and the serum triglyceride value (range: 60–825 mg/dl) was greater than 180 mg/dl in 69 patients (20%). A total of 196 patients (57%) either smoked cigarettes or had discontinued their chronic use of cigarettes less than five years before their operations.

### Preoperative Cardiac Status

No history of previous CAD symptoms or known cardiac disease could be elicited from 220 patients

(64%). Historic information obtained from the remaining 123 patients, their families, or their referring physicians was consistent with previous myocardial infarction in 49 patients (14%), angina pectoris in 33 patients (10%), congestive heart failure in six patients (2%), arrhythmias requiring medical management in five patients (2%), and two or more of these factors in 30 patients (8%).

The preoperative electrocardiogram (EKG) was normal in 132 patients (38%). Previous myocardial infarction was documented by EKG evidence in 77 patients (22%) while 121 patients (35%) had ischemic myocardial changes within the ST-T segments. Eight patients (3%) had arrhythmias on preoperative EKG tracings, and five patients (2%) had two or more abnormal EKG findings.

Graphic representation of the preoperative cardiac status indicated by historic and EKG data is given in Figure 1. Although historic questioning may have been omitted in some patients who had ruptured aneurysms because of the urgency with which such patients are prepared for immediate operation, no statistically significant differences in the incidence of abnormal

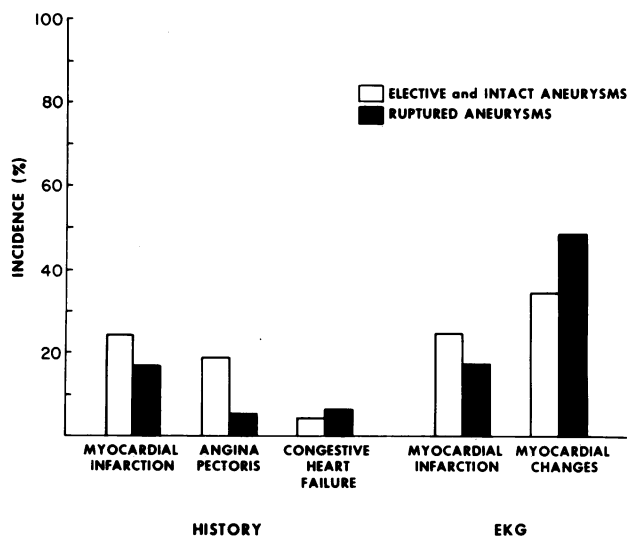


FIG. 1. Preoperative cardiac status for 343 patients according to history and EKG findings.

TABLE 2. *Fatal Postoperative Complications*

Principal Cause of Death	Elective (251 Patients)		Symptomatic Intact (49 Patients)		Ruptured (43 Patients)		Total (57 Patients)	
	Number of Patients	Per Cent	Number of Patients	Per Cent	Number of Patients	Per Cent	Number of Patients	Per Cent
Myocardial infarction	9	38	5	39	7	35	21	37
Pulmonary failure	6	25	1	8	2	10	9	15
Hemorrhage	2	8	2	15	4	20	8	14
Renal failure	2	8	0	—	3	15	5	9
Pulmonary embolism	1	4	3	23	0	—	4	7
Stroke	1	4	0	—	1	5	2	4
Graft infection	0	—	0	—	1	5	1	2
Other	3	12	2	15	2	10	7	12
Total	24	100	13	100	20	100	57	100
Per Cent of Group	9.6		26.5		46.5		16.5	

EKG findings are present in these two groups. Considering those features which are most suggestive of CAD by history (previous myocardial infarction, angina pectoris) or by EKG findings (previous myocardial infarction, ischemic myocardial changes), 105 patients (31%) had no preoperative evidence of CAD, 25 patients (7%) had CAD by history alone, 112 patients (33%) had CAD on the basis of EKG findings alone, and 79 patients (23%) had CAD according to both history and EKG information. A small group of 22 patients (6%) had nonspecific EKG abnormalities such as arrhythmias or conduction defects, and are included among those suspected to have CAD in subsequent life table data in this report.

## Results

### Postoperative Mortality

The principal causes of early postoperative death are given in Table 2. A total of 57 patients (16.6%) in the entire series died within 30 days of operation. The operative mortality rate was 9.6% in the elective group, 26.5% in the symptomatic group without rupture, and 46.5% in the ruptured group. Myocardial infarction was the leading cause of death in all groups and accounted for 37% of postoperative deaths in the entire series, a figure representing twice as many deaths than were caused by pulmonary failure, the next most common source of early mortality. Fatal postoperative myocardial infarctions occurred in 6% of the 343 patients in this study.

Preoperative atherosclerotic risk factors were not associated with statistically significant differences in postoperative mortality. Considering both intact and ruptured aneurysms, the operative mortality rate did increase with advancing age (Fig. 4) but increased risk appeared to be limited to a small group of 13 patients over 80 years of age. In addition, 60 patients (18%) had nonfatal cardiac complications, including myocardial infarction in four patients, arrhythmias requiring

medical management or cardioversion in 39 patients, and congestive heart failure in 17 patients.

### Late Mortality Rate

Fourteen patients (4%) were lost to follow-up during the maximum observation interval of 11 postoperative years. The principal causes of late mortality among 286 operative survivors in this series are given in Table 3. A total of 150 patients (53%) have died, and myocardial infarction was the principal cause of death in 62 patients (41%). Myocardial infarction was responsible for three times the number of late deaths produced by either of the next leading sources of late mortality, malignant neoplasm or stroke.

Complete life table data for the 286 patients who survived operation are given in Table 4. Eighty-eight patients (31%) died within five years of operation. Myocardial infarction was the principal cause of death in 34 patients, accounting for 39% of the deaths and affecting 12% of those patients who survived aneurysm resection. Of the 198 patients who lived at least five years after operation, 62 patients (31%) subsequently died within five to 11 years. Myocardial infarction was responsible for 28 (45%) of these deaths, affecting 14%

TABLE 3. *Causes of Late Mortality Among 286 Operative Survivors from One to 11 Years After Operation*

Principal Cause of Death	Number of Patients	Per Cent of Deaths	Per Cent of Operative Survivors
Myocardial infarction	62	41	22
Malignant neoplasm	21	14	7
Stroke	16	11	6
Chronic pulmonary disease	11	8	4
Chronic renal disease	8	5	3
Graft infection	5	3	2
Ruptured thoracic aneurysm	5	3	2
Pulmonary embolism	3	2	1
Other	18	12	6
Total	150	100	53

TABLE 4. Complete Life Table Data for 286 Operative Survivors

Post-operative Year	Number of Patients Alive at the Beginning of the Year	Number of Patients Lost to Follow-up During the Year	Number of Patients Alive Observed for Only Part of the Year	Number of Patients Exposed to Risk of Dying During the Year	Number of Patients Dying During the Year	Proportion of Patients Dying During the Year	Proportion of Patients Surviving the Year	Proportion of Patients Alive to End of the Year
1	286	0	0	286	20	0.070	0.930	0.930
2	266	9	0	261.5	8	0.031	0.969	0.901
3	249	1	0	248.5	20	0.080	0.920	0.829
4	228	1	0	227.5	17	0.075	0.925	0.767
5	210	0	0	210	23	0.110	0.890	0.683
6	187	1	0	186.5	14	0.075	0.925	0.632
7	172	2	46	148	20	0.135	0.865	0.547
8	104	0	23	92.5	10	0.108	0.892	0.488
9	71	0	22	60	10	0.167	0.833	0.407
10	39	0	17	30.5	4	0.131	0.869	0.354
11	18	0	14	11	4	0.364	0.636	0.225

of the five-year survivors. A total of 62 (22%) of the 286 operative survivors had fatal myocardial infarctions during the full follow-up interval of 11 years.

Considering all 343 patients in this series, 238 patients had some indication of CAD on the basis of their previous cardiac history or preoperative EKG findings while 105 patients had no clinical evidence of CAD. Graphic representation of life table data for these groups is compared to that of a normal 1970 male population of the same age (66 years of age)<sup>16</sup> in Figure 2. The postoperative mortality rate was 7.6% for patients without preoperative evidence of CAD, 20.6% for those with suspected CAD, and 16.6% for the total series. The five- and 11-year survival rates were 72 and 25% for patients without evidence of CAD, 45 and 14% for those patients suspected to have CAD, and 57 and 18% for the total series. Statistical analysis of survival curves<sup>3</sup> was restricted to five-year data because of the limited number of patients still available

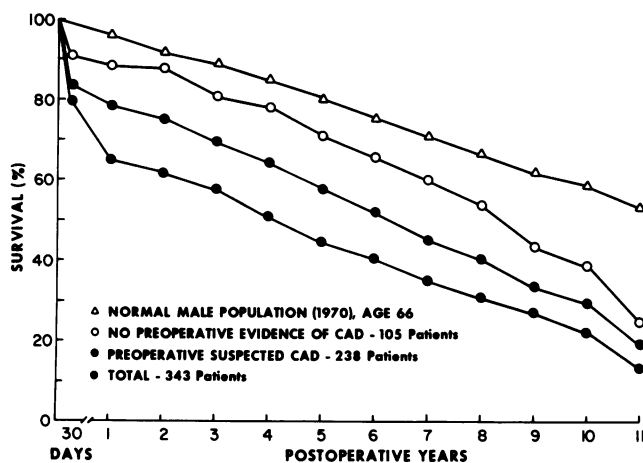


FIG. 2. Life table survival curves for 343 patients, including postoperative mortality, in comparison with that of a normal male population.<sup>16</sup>

for study at 11 postoperative years. Differences in postoperative mortality and five-year survival rates between patients suspected to have CAD on the basis of preoperative history and EKG findings and those without clinical indications of CAD were statistically significant ( $p < 0.05$ ).

Figure 3 presents graphic representation of life table data for 286 operative survivors in this series according to whether preoperative evidence of CAD was present, together with similar information for a group of 601 patients with known CAD documented by coronary angiography at the Cleveland Clinic which has previously been reported by Proudfit and associates.<sup>12</sup> Statistical analysis confirmed significant differences in five-year survival rates between patients in this series with no preoperative indication of CAD and those suspected to have CAD ( $p < 0.05$ ). Moreover, there

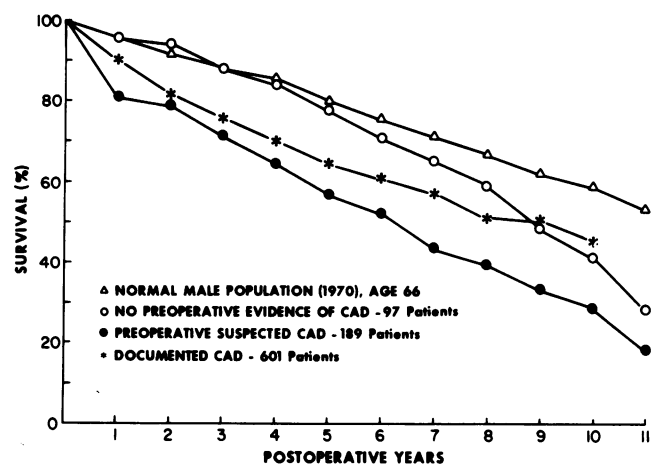


FIG. 3. Life table survival curves for 286 operative survivors in comparison with a group of 601 patients with CAD documented by coronary angiography.<sup>12</sup> Reprinted with permission from Proudfit WL, Bruschke VG, Sones FM. Natural history of obstructive coronary artery disease: 10 year study of 601 nonsurgical patients. *Progr Cardiovasc Dis* 1978; 21:56.

was no statistical difference in survival rates between patients suspected to have CAD in this series and those with proven CAD described by Proudfit.

The influence of age at the time of operation on postoperative mortality rates, (five- and 11-year mortality rates) and the incidence of fatal myocardial infarction is shown in Figure 4. With the exception of patients over 80 years of age, approximately 15% of each group died with fatal myocardial infarctions within five years of operation although the total five-year mortality rate ranged between 28% for patients under 60 years of age to 49% to those between 70 years and 80 years of age. However, death from myocardial infarction occurred in 33% of the patients less than 60 years of age when follow-up study was extended to 11 years and accounted for 67% of all late deaths within this age group.

Information concerning postoperative and late mortality rates for patients who underwent elective aneurysm resection during each year of this study is given in Figure 5. The operative mortality rate was reduced to a mean of 4.6% from 1971 through 1973. Nevertheless, 66 (43%) of the 153 patients who underwent operations during these years have subsequently died. Thirty-six (54%) of these deaths were caused by myocardial infarction.

*Correlation with Preoperative Risk Factors*

The preoperative cardiac status is correlated with the incidence of fatal myocardial infarction during the early postoperative and late follow-up periods in Table 5. Chi square analysis confirmed significant differences in the incidence of fatal myocardial infarction during

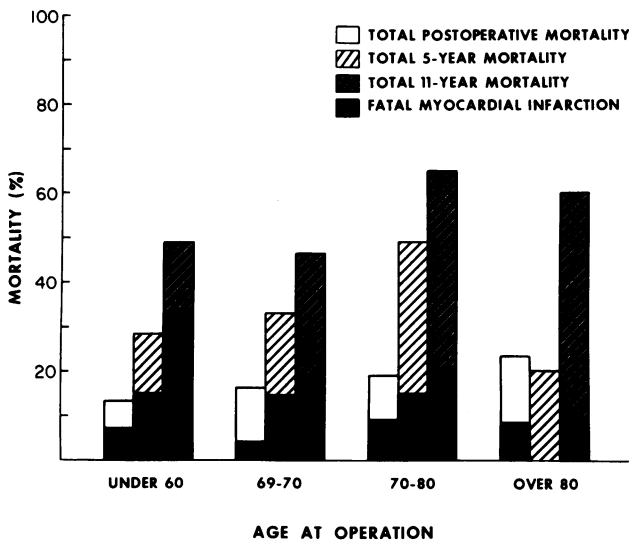


FIG. 4. Comparison of postoperative and late mortality for 343 patients according to age at the time of operation.

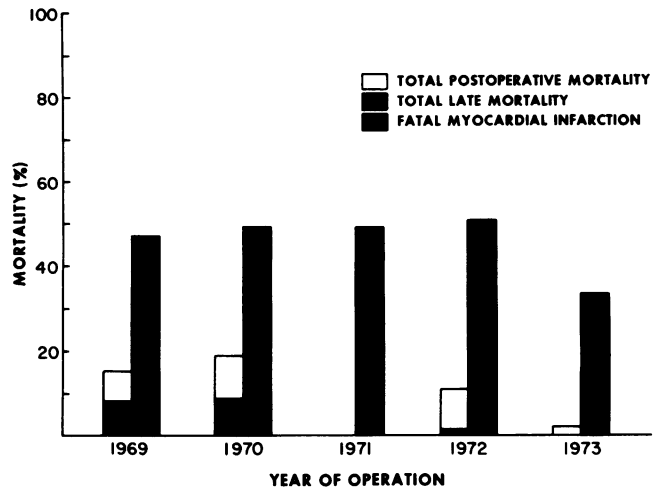


FIG. 5. Postoperative and late mortality for 251 patients who had elective aneurysm resection according to the year of operation.

the immediate postoperative period ( $p < 0.02$ ) and during the late follow-up interval ( $p < 0.05$ ) between patients with no preoperative evidence of CAD and those who had both a positive cardiac history as well as abnormal EKG findings. Statistical testing suggested but did not confirm ( $0.05 < p < 0.1$ ) that late death from myocardial infarction was more likely to occur among patients who had abnormal EKG findings associated with prior cardiac symptoms than among those with incidental, asymptomatic EKG findings alone.

Among preoperative atherosclerotic risk factors, only diabetes mellitus had a statistically significant correlation with late mortality caused by myocardial infarction. Sixty-two diabetics and 224 nondiabetics survived aneurysm resection. Of these, 27 diabetics (44%) and 61 nondiabetics (27%) died within five years of operation ( $p < 0.025$ ), and myocardial infarction was the principal cause of death in 16 patients (26%) and 18 patients (8%), respectively ( $p < 0.0005$ ). A total 11-year mortality rate of 56% for diabetics and 51% for nondiabetics was comparable, but the incidence of fatal myocardial infarction of 34% among diabetics was significantly greater ( $p < 0.025$ ) than that among nondiabetics (18%).

**Discussion**

The results of this study suggest that late survival among patients who have any indication of CAD on the basis of previous cardiac symptoms or abnormal EKG findings at the time of abdominal aortic aneurysm resection is more closely comparable to survival demonstrated by patients with significant CAD documented by coronary angiography than to that of the normal population of the same age. Patients with preoperative evidence of CAD sustained a statistically

TABLE 5. Total Incidence of Fatal Myocardial Infarction According to Preoperative Cardiac Status\*

Preoperative Cardiac Status	Patients	Fatal Myocardial Infarction			
		Postoperative		Late (1-11 years)	
		Number of Patients	Per Cent	Number of Patients	Per Cent
Negative cardiac history and normal EKG	105	2	2	15	15
Previous myocardial infarction or angina by history alone	25	2	8	8	35
Previous myocardial infarction or myocardial changes on EKG alone	112	8	7	17	16
Positive cardiac history and abnormal EKG	79	9	11	22	31

\* Late incidence calculated on the basis of operative survivors.

significant number of fatal myocardial infarctions throughout the 11-year follow-up interval, and late death from complications of CAD appeared to be especially prevalent among diabetics and among patients less than 60 years of age at the time of aneurysm resection. Improvement in the postoperative mortality rate recorded during the last three years of this study was not accompanied by a reduction in the incidence of fatal myocardial infarction within a few years following successful operation.

Trends in early and late mortality rates of the 343 patients in this series are similar to those described in previous reports concerning patients who underwent abdominal aortic aneurysm resection a decade ago.<sup>1,7,15,17</sup> Hicks and associates<sup>7</sup> reported an operative mortality rate of 2-12% in a collected series of elective aneurysm resections and, in their own experience, encountered an operative mortality rate of 8.4% which occurred exclusively among patients with preoperative evidence of CAD. Young and associates<sup>17</sup> reported an operative mortality rate of 6.3% for elective aneurysm resection but found that 20% of the patients with preoperative evidence of CAD had postoperative myocardial infarctions, of which 58% were fatal.

Although advances in the technology of postoperative surgical care have enhanced the safety of elective aneurysm resection during the past 15 years, the impact of fatal myocardial infarction on the late survival rate following successful operations has remained remarkably constant. Considering all patients in this report, the postoperative survival rate at five years and at ten years was 57 and 30%, respectively. Fatal myocardial infarctions caused 39% of the deaths that occurred within five years of operation and 41% of the deaths that occurred within ten years. In 1964, DeBakey and associates<sup>4</sup> reported five- and ten-year survival rates of 58 and 30%, respectively, following aneurysm resection. Forty-four per cent of the patients with preoperative evidence of CAD died during the late follow-up interval. In 1966, Szilagyi and associates<sup>14</sup>

reported five- and ten-year survival rates of 49 and 28%, respectively, following aneurysm resection. Cardiac disease was responsible for 38% of all late deaths.

In a subsequent publication, Szilagyi and associates<sup>13</sup> described the courses of 156 patients who had not been considered to be suitable candidates for elective aneurysm resection. These included 59 patients in whom suspected cardiac disease was cited as the contraindication to operation. Of 127 patients who never underwent aneurysm resection, 71% died during the observation period, and 69% of all deaths were caused by either myocardial infarction or aneurysm rupture. Flanigan and associates<sup>5</sup> recently described a mortality rate of 48% among a similar series of 153 patients with known abdominal aortic aneurysms who did not undergo elective operation. Myocardial infarction or aneurysm rupture caused 59% of all deaths in this series, including 80% of the deaths among patients who had been denied elective aneurysm resection because of suspected CAD. Elective aneurysm resection clearly is the most logical form of management for such patients if it can be performed with a reasonable margin of safety.

As late follow-up information concerning patients with documented CAD who undergo direct myocardial revascularization with the use of coronary artery bypass grafts has been accumulated, several reports have implied that such patients sustain fewer cardiac complications after subsequent vascular and other major operations than otherwise would be expected.<sup>2,10,11</sup> Crawford and associates<sup>2</sup> presented a series of 358 patients who underwent 484 subsequent operations at various intervals following direct myocardial revascularization, including 308 vascular procedures in 232 patients. Only four operative deaths (0.8%) occurred following these subsequent procedures, and only 12 patients (3%) died from cardiac causes within a five-year follow-up period. Other reports<sup>8,9</sup> from medical centers with extensive experience with coronary artery

bypass indicate that five-year survival rates of 90% or greater may be expected following direct myocardial revascularization even in patients who previously had CAD involving multiple coronary arteries.

Considering the ominous implications of CAD in patients with abdominal aortic aneurysms, routine preoperative coronary angiography has been recommended to all patients under consideration for elective aneurysm resection at the Cleveland Clinic since 1978. Data concerning the incidence of significant CAD which may be detected using such an approach and the safety with which elective aneurysm resection may be performed following coronary artery bypass procedures in patients found to have severe CAD have previously been presented.<sup>6</sup> Although late follow-up information is not yet available for patients whose management presently is determined with the use of routine preoperative coronary angiography, this report describes an historic control group with which such patients will eventually be compared in an effort to define those patients for whom preoperative coronary angiography is advisable for safe aneurysm resection and improved late survival rates.

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