Coronary Artery Disease in Patients Requiring Abdominal Aortic Aneurysm Repair

Selective Use of a Combined Operation

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The chief cause of operative mortality after abdominal aortic aneurysm (AAA) repair is myocardial infarction. For this reason, routine coronary angiography followed by prophylactic coronary artery bypass grafting (CABG) prior to AAA repair has been recommended by some surgeons. We report here the results of the selective use of a combined operation. Two hundred twenty-seven patients had elective or emergency repair of nonruptured AAA on our service from 1972 to 1983. Prior to surgery, all patients underwent careful clinical evaluation for the presence of coronary artery disease (CAD) and were classified into the following: group I (n = 121), no clinical evidence of CAD, 53%; group II (n = 96), clinical evidence of stable CAD, symptomatic or asymptomatic, 42%; group III (n = 10), unstable CAD, five per cent; Group IIIa (n = 4), asymptomatic AAA; and group IIIb (n = 6), symptomatic AAA. Seven patients ultimately assigned to group II underwent stress electrocardiogram (ECG) and eight group II patients had coronary angiography before surgery. All patients in groups I and II underwent elective or urgent repair of their AAA without CABG. Prior to surgery, these patients were managed with placement of a pulmonary artery catheter and incremental volume loading to construct a left ventricular performance curve as a guide to surgical fluid replacement. All were carefully monitored for at least 48 hours after surgery in an intensive care unit. Four patients (group IIIa) with unstable CAD and asymptomatic AAA underwent CABG followed by elective AAA repair within six months. Six patients (group IIIb) with unstable CAD and symptomatic AAA underwent combined open heart surgery (CABG and, in one patient, valve replacement) and AAA repair as a single operation. There was no operative mortality in group III patients. Thirty-day operative mortality for the entire group of 227 patients was 1.3% (three deaths), with only one death from a myocardial infarction (0.4%). While there is clearly a high incidence of CAD in patients with AAA, the present results indicate that these individuals can be managed with low risk by a selective approach based upon clinical assessment of their CAD. Our experience further demonstrates that patients with unstable CAD and symptomatic AAA may have both lesions safely repaired as a single operative procedure.

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THE REPAIR OF an abdominal aortic aneurysm (AAA) has become a commonly performed operation with an acceptable morbidity and mortality despite the coexistence of clinically significant coronary artery disease (CAD) in many of these patients. In an attempt to lessen the influence of CAD on operative mortality, several reports have recently recommended routine coronary angiography and prophylactic coronary revascularization when indicated prior to AAA repair.[1–3] It remains our belief that patients undergoing AAA repair can be managed safely with a more selective approach. We report here our experience over the past decade with repair of 227 nonruptured AAAs. The extent of the cardiac work-up prior to surgery was determined by clinical assessment of the severity of the patient's coronary artery disease. Using this approach, four patients (two per cent of the total) were selected for coronary artery bypass grafting prior to elective repair of their asymptomatic AAA. However, we also identified a subset of six patients (three per cent of total) who had unstable cardiac disease as well as symptomatic AAA. In all six patients, both lesions were repaired successfully as a single operative procedure.

Methods

Patient Population

From July 1972 to June 1983, 227 consecutive patients underwent elective or urgent repair of an intact infrarenal AAA (Table 1) on our vascular surgical service. There were 184 men (80%) and 43 women (20%) with an average age of 68 years (range 42 to 94 years). The average aneurysm at surgery measured 7 cm in maximum diameter (30% between 5 and 6 cm; 70% greater than 6 cm). Fifty AAAs were symptomatic and 177

TABLE 1. *Patient Profiles*

Total number of patients	227
Total number AAA repairs	227
Men:women	184:43
Age range, years	42–93
Average age, years	68
Average aneurysm size, cm	7
AAA: Asymptomatic	177
Symptomatic	50

were asymptomatic. The vast majority of patients had at least one associated operative risk factor (Table 2). Forty-seven per cent of patients were noted to have clinically significant CAD, as judged by symptoms and/or findings on ECG.

Perioperative Management

Our perioperative management of patients undergoing AAA repair is described in detail in a previous report.[4] All patients in this series had placement of pulmonary and radial artery catheters and underwent incremental volume loading to determine a left ventricular performance curve prior to surgery. An appropriate pulmonary wedge pressure was selected which was associated with a desirable cardiac output and served as a guide to fluid administration during the operation.

Operative Technique

All aneurysms were repaired using the graft inclusion technique as described by Javid[5] and Creech.[6] Details of this technique are also described in a previous report.[4]

Cardiovascular Classification

A detailed cardiovascular evaluation was done on each patient. Patients were classified into one of three groups based on their clinical cardiac evaluation (Table 3). Group I consisted of 121 patients (53%) with no symptoms suggestive of coronary artery disease and a normal ECG. Group II consisted of 96 patients (42%) who were judged to have clinically stable coronary artery disease (symptomatic or asymptomatic). Inclusion in this category was based on the presence of angina or a past history of myocardial infaction and/or changes on the ECG suggestive of a past myocardial injury. Group III was composed of ten patients with unstable coronary artery disease unresponsive to medical therapy and documented in each case with coronary angiography. Four patients (IIIa) had asymptomatic aneurysms and underwent coronary-artery-bypass grafting followed by elective AAA repair within the subsequent six months. Six patients (IIIb) had concurrent symptomatic aneurysms and unstable cardiac disease and were operated on by the Cardiac and Vascular Surgical Services as a combined procedure. At operation, all aneurysms were noted to be intact, but there was evidence of recent expansion.

TABLE 2. *Associated Risk Factors*

	Number of Patients	Per cent
Coronary artery disease	106	47
Hypertension	72	31
Peripheral vascular disease	29	12
Cerebrovascular disease	15	6
Diabetes mellitus	16	7
Chronic obstructive pulmonary disease	16	7
Chronic renal disease	7	3

Long-term Follow-up

Follow-up information was available on 220 patients. Each survivor was contacted by telephone or seen in our office within 3 months of this writing. Five-year cumulative survival data were determined using life table methods.[7]

Results

Early Morbidity/Mortality

The overall 30-day mortality in this series was 1.3% (three deaths). Two patients sustained fatal pulmonary emboli. One death was attributable to a myocardial infarction (0.4%). Early complications after surgery are listed in Table 4. These occurred in 20% of patients. Myocardial infarction occurred in seven patients, (three per cent), but only one resulted in hemodynamic instability.

Late Follow-up

Long-term follow-up was possible in 97% of patients. Using standard life table analysis, the 5-year cumulative survival rate was 77% (Table 5). There were a total of 44 late postoperative deaths. The cause of death was known in 19 patients, and was attributable to myocardial infarction in nine (47%) of these. The survival curve for this group of 227 AAA repairs is illustrated in Figure 1.

TABLE 3. *Clinical Cardiac Classification System*

Group	Number of Patients	Per cent	Characteristic
I	121	53	No clinical evidence of CAD
II	96	42	Clinical evidence of stable CAD, symptomatic or asymptomatic
III	10	5	Unstable CAD
IIIa	4		Asymptomatic AAA
IIIb	6		Symptomatic AAA

TABLE 4. *Early Postoperative Complications*

Complication	Number
Cardiovascular	
Myocardial Infarction—hemodynamically significant	1
—no hemodynamic significance	6
Arrythmia	5
Peripheral emboli	2
Cerebrovascular accident	1
Renal	
Acute renal failure	4
Chronic renal failure	0
Pulmonary	
Pneumonia	6
Pulmonary embolus	2
Gastrointestinal	
Colon infarction	2
Upper GI bleed	1
Pseudomembranous colitis	1
Small bowel obstruction	1
Diverticulitis	1
Pancreatitis	1
Miscellaneous	
Urinary sepsis	5
Re-exploration hemorrhage	4
Wound dehiscence	2
Staphylococcus septicemia (source unknown)	1

Associated Procedures

Several additional operative procedures were performed at the time of aneurysm repair (Table 6). As noted, six patients underwent repair of unstable cardiac disease during the same operation, just prior to aneurysm repair. Six nephrectomies were performed because of non-functioning kidneys in the setting of renin-mediated hypertension. There were five renal artery reconstructions. One inferior mesenteric artery was re-implanted in a patient with a chronic occlusion of the celiac axis and superior mesenteric artery. The inferior vena cava was interrupted with a clip in a patient with a past history of pulmonary emboli. The femoral embolectomies and two femoro-femoral bypasses were required to re-establish circulation to the legs. Cholecystectomy was performed in three patients for chronic cholecystitis, and two splenectomies were performed because of intraoperative lacerations of the spleen.

TABLE 5. *Cumulative 5-year Survival Following AAA Repair*

Interval after Surgery	Patients Entering Interval	Number of Deaths	Number of Lost	Number of Withdrawn	Cumulative Fraction Survival Interval
6 mo	227	11	1	5	0.95
1 yr	210	3	1	18	0.94
2 yr	188	9	0	23	0.89
3 yr	156	2	1	39	0.88
4 yr	114	4	2	33	0.84
5 yr	75	6	2	23	0.76

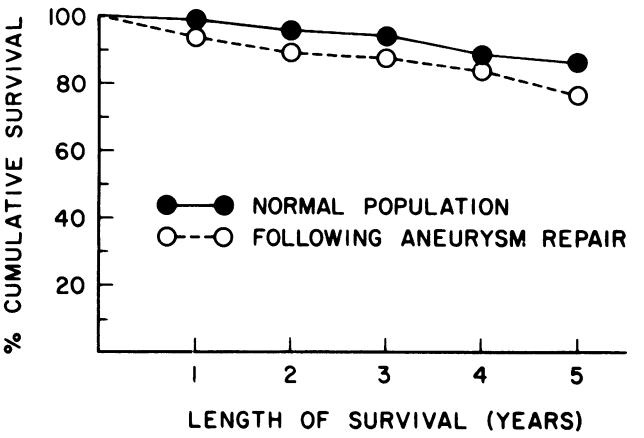

FIG. 1. Cumulative survival of patients in the present series (O - - - O) compared with a normal population of equivalent age and sex (● —— ●). There is no significant difference between the two curves.

Influence of Coronary Artery Disease

Group I. The patients in this group did not have clinically evident coronary artery disease (53%). There were no operative deaths or perioperative myocardial infarctions in this group.

Group II. The patients in this group were judged to have stable cardiac disease (43%). Four patients had undergone CABG at some time in the distant past. Selected patients were subjected to more extensive cardiac evaluation than patients in group I. Stress ECG was performed in seven group II patients prior to AAA repair and three of the seven tests were positive. Two of these three patients and six additional patients in group II underwent coronary angiography prior to AAA repair. While coronary artery disease was noted in all angio-

TABLE 6. *Associated Procedures*

Procedure	Number
Cardiac	
Coronary artery bypass	5
Aortic valve replacement	1
Renal	
Nephrectomy	6
Renal artery reconstruction	4
Reimplant renal artery	1
Other vascular	
Femoral embolectomy	10
Femoral-femoral bypass	2
Reimplant IMA	1
Inferior vena cava clip	1
Miscellaneous	
Cholecystectomy	3
Splenectomy	2
Excision of ovarian tumor	1
Resection of pheochromocytoma	1
Suprapubic cystoscopy	1
Hernia repair (incisional)	2

grams, none of these patients was felt to require coronary artery bypass grafting. Noninvasive cardiac evaluation was accomplished in four patients with a thallium scan. Results of this test however did not influence the management of these patients. All group II patients underwent elective or urgent AAA repair in the same manner as group I patients. The seven myocardial infarctions occurring after surgery occurred in patients in group II, however only one was associated with hemodynamic instability and resulted in the only cardiac-related death in this series.

Group IIIa. Four patients (2%) were judged to have unstable coronary artery disease and asymptomatic aneurysms. These patients all had coronary artery bypass grafting followed by elective AAA repair within six months. There was no operative mortality or myocardial infarction in this group.

Group IIIb. Six patients had concurrent unstable cardiac disease as well as symptomatic aneurysms. Critical aortic stenosis with congestive heart failure was present in one patient, while five patients had crescendo angina unresponsive to medical therapy. After emergency angiographic studies of the coronary arteries and the abdominal aorta, all patients had their cardiac lesions and AAA repaired during the same operation. After completion of coronary grafting, and in one instance aortic valve replacement, the patient was taken off bypass and the heparin neutralized with protamine. The median sternotomy was left open, a long midline abdominal incision was made and the aneurysm repaired using standard technique. There was no operative mortality or cardiac morbidity in this group of patients.

Discussion

The combination of modern surgical technique, improved anesthetic management, and sophisticated monitoring has undoubtedly contributed to a lowering of the operative mortality associated with AAA repair. In 1969, Young et al.[9] reported a 15% operative mortality for elective aneurysm repair. The same group achieved a lowering of operative mortality to six per cent in a report in 1977.[10] Crawford has reported a 1.43% operative mortality in his most recent series of 368 patients undergoing AAA repair.[11] Our institution has previously reported 110 AAA repairs performed with no 30-day operative mortality.[4] We have now updated our experience and report a 1.3% operative mortality in our last 227 consecutive, urgent, and elective aneurysm repairs.

We believe that a major contributing factor to low operative mortality is the perioperative management of these patients. A pulmonary artery catheter is placed before surgery and a myocardial performance curve is determined for each patient. A pulmonary artery wedge pressure that results in a cardiac output considered appropriate for that patient is chosen, and perioperative fluid replacement is adjusted to maintain that wedge pressure. All patients in the present series, regardless of their existing cardiac status, were managed in this manner.

It is well-known that there is a high incidence of CAD in patients with abdominal aortic aneurysms,[3] and this is corroborated by our findings of a 47% incidence of clinically-significant CAD in the present series. The actual influence of CAD on operative mortality is not known because of conflicting reports in the literature. Hertzer[11] has reported that 40% of all deaths following AAA repair were due to myocardial infarctions. In a detailed study, Cooperman[12] assessed cardiovascular risk factors in patients undergoing major vascular procedures and found that 62% of deaths were cardiac-related. Contrary to these findings, Crawford[11] reviewed a group of 60 patients with known CAD undergoing AAA repair with no operative deaths. Despite a large number of patients with clinically significant CAD in our present series, the incidence of early cardiac-related death was 0.4%.

Late survival following aneurysm repair seems to be directly influenced by coronary artery disease. Hollier[13] has demonstrated a 5-year survival of 67% in a recent series of aneurysm repairs. Late deaths were attributable to cardiac-related disease in 38% of patients. This is comparable to the 77% 5-year survival rate in our series in which 47% of late deaths were the result of CAD.

Aneurysm repair poses a significant stress of the myocardium, which may be accentuated by the presence of CAD. The hemodynamic response to cross-clamping of the aorta has been studied by Attia, and colleagues.[14] They have demonstrated that patients with clinically evident coronary artery disease experienced an increase in their pulmonary capillary wedge pressure which was associated with ischemic ECG changes. Bush et al.[15] reported no operative mortality and little depression of cardiac performance on aortic cross-clamping in a small group of patients with CAD undergoing AAA repair. He attributed these findings to appropriate preoperative volume loading which allowed the left ventricle to perform optimally. Again, this is a principle of perioperative management which we feel contributes to the low operative mortality in our present series.

In an attempt to minimize cardiac causes of operative mortality, Hertzer has recommended routine coronary and angiography for all patients prior to AAA repair.[1] He has performed coronary angiography in a group of patients with AAA and no history of cardiac disease and has documented an 18% incidence of surgically correctable CAD.[2] Based on these findings, CABG was performed on 37% of patients prior to their aneurysm

repair. The overall operative mortality for patients with AAA, managed with this protocol was 3.9%.[3] We do not doubt the high prevalence of CAD in patients with AAA, but we question the need to perform prophylactic CABG in a high percentage of patients in order to decrease operative mortality.

Conclusion

It is not always possible to accurately predict those patients who will be at highest risk for a myocardial infarction during AAA repair. A multivariate analysis of cardiac risk factors in patients undergoing AAA repair showed that many patients with low computed risk will experience cardiac complications.[12] Routine exercise-tolerance testing has been shown to have limited value in predicting the presence of CAD in patients with no history of cardiac disease and normal laboratory data.[16] In addition, it has not been shown to be an accurate screening test because of the high percentage of false-positive results as indicated by subsequent coronary angiograms.[17] As pointed out by Goldman,[18] routine coronary angiography is not indicated for patients with stable angina because the risks of catheterization and CABG may be greater than the risk of undergoing a noncardiac surgical procedure.

Acceptable operative mortality in AAA repair can be achieved with a selective approach to problems of coronary artery disease. Patients in our institution with AAA and clinically stable coronary artery disease (group II) are managed in the same manner as asymptomatic patients (group I) and are generally not subjected to a more extensive cardiac evaluation. Exercise testing and coronary angiography are reserved for patients with clinical evidence of unstable coronary artery disease or those in whom this issue remains in doubt after a careful history, physical examination and ECG. Eight patients in the present series were deemed not to require coronary artery bypass grafting after coronary angiography and underwent uncomplicated AAA repair. However, there is a subset of patients with AAA, 10 in the present series, who have unstable, symptomatic CAD. If the aneurysms are asymptomatic, we manage these patients with coronary artery bypass followed by AAA repair at a later date. Several authors[19–21] have demonstrated that prior CABG can exert a protective effect on the myocardium for subsequent aneurysm repair or peripheral arterial surgery.

Over the past decade, we have encountered six patients who had symptoms suggesting acute aneurysm expansion as well as unstable coronary disease unresponsive to medical therapy. Despite the large magnitude of such an undertaking, we recommended that these patients have both lesions repaired as a single operative procedure. Since there has been no operative mortality in this group, we believe this approach may deserve application in other centers to patients with symptomatic aneurysms and unstable cardiac disease.

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