The Improving Long-term Outlook for Patients over 70 Years of Age with Abdominal Aortic Aneurysms

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During the past decade, selective criteria for elective surgery for abdominal aortic aneurysms have been refined based on natural history and aneurysm expansion information. Using these criteria, contemporary preoperative preparation and newer intraoperative technical adjuncts, 123 consecutive patients underwent elective resection with 1 death (mortality rate: 0.8%). These include all patients operated on with both elective and urgent aneurysms at this institution since 1978, with the exception of those with frank rupture. Most importantly, however, the 5-year life-table survival of all of these patients (average age: 71.3 years, range 46–96 yr) was 72%, including both hospital and late mortality rates. More than half of the patients were over 70 years old (78 cases), with no hospital deaths and a 5-year life-table survival probability of 67%. For those under 70 years of age at the time of operation, the 5-year life-table probability of survival was 79%. We believe that these accomplishments were a direct result of an aggressive policy of screening for and selectively treating coronary disease and carotid stenosis preoperatively and the utilization of such intraoperative adjuncts as routine Swan-Ganz monitoring, autologous blood transfusion, the cell saver, and the frequent use of the tube grafting (50%). Thus, with proper selection, the outlook for the patient over 70 years old with an elective abdominal aortic aneurysm resection now approaches that of the normal population (67% *vs.* 69%).

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REFINED DIAGNOSTIC TECHNIQUES for infrarenal abdominal aortic aneurysms have made it possible to identify patients at risk from this condition at an earlier stage, and permit a more careful evaluation of aneurysm size and associated risk factors.[1,2] Long-term follow-up of unoperated patients with small abdominal aortic aneurysms by ultrasound, and more recently by CT scanning, has determined the mean expansion rate for aneurysms under 6 cm in size to be 4 mm/yr.[2] Thus, surgical selection has improved parallel to advancing surgical management techniques for such patients. As a result, the mortality rate associated with elective surgery for abdominal aortic aneurysms has decreased significantly each of the last several decades.[3–7] More important, however, has been the effect of improvement in diagnosis, selection, and management on the longevity of patients with this condition.

The opening of the Green Hospital of Scripps Clinic in 1978 permitted the acquisition of data regarding all patients operated on in this center by two surgeons (E.F.B. and R.B.D.) with a single protocol since the inception of surgical activity. This report summarizes our initial experience with elective surgery for abdominal aortic aneurysm at the Scripps Clinic.

Materials and Methods

One-hundred twenty-three consecutive patients were subjected to elective surgery for abdominal aortic aneurysms from January 1, 1978 through December 1985. Their charts were surveyed for data regarding aneurysm size, general physical condition, presence of associated risk factors, and prior cardiovascular surgery. In addition, the preoperative angiograms were reviewed for documentation of additional para-aneurysmal disease, and particularly for unusual renal arterial anatomy, renal artery stenoses, and anomalies. Operative reports were abstracted to obtain data regarding aneurysm size, anesthetic time, operative time, aortic cross-clamp time, type of graft implanted, utilization of the cell saver, and operative blood loss. Information was also obtained regarding operative mortality and hospital morbidity rates, and all data were categorized by patient age. All surviving patients were contacted to determine their current health status, and an effort was made to deter-

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mine the time and cause of death of all patients who died. Such information was obtained by review of the patients' charts, contacting the Bureau of Vital Statistics of San Diego County, and direct written or verbal contact with the patient, the family or personal physician. Every effort was made to confirm the final cause of death from autopsy or death certificate information.

All data were entered on a VAX 11/750 computer using CLINFO software for clinical research management analysis. Life-table analyses were performed according to the procedure of Kaplan and Meier[8] and Gehan.[9]

Selection for Surgery

General criteria for operative intervention included all aneurysms of 5 cm or more in largest transverse diameter in good risk patients. Noninvasive tests were routinely used to confirm the diagnosis and to estimate aneurysm size. During the earlier years of the study, ultrasound was the predominant method of noninvasive examination, but more recently CT scanning has been used liberally and is now considered the diagnostic technique of choice. All patients with symptomatic aneurysms were operated on, regardless of patient's age or aneurysm size. Included in these data are all patients with urgent procedures in whom the aneurysm was discovered to be intact at the time of surgery.

Questionable operative indications. Contraindications to surgery included a myocardial infarction within 3 months, the presence of intractable congestive heart failure, dyspnea at rest, permanent significant residual neurologic deficit from stroke, or advanced renal disease with a creatinine of 3 or greater. In addition, the presence of other terminal diseases with a life expectancy of less than 3 years was considered a contraindication to elective surgery. Poor risk patients with small asymptomatic abdominal aneurysms (less than 6 cm) were followed routinely at 3-month intervals with echography or CT scanning and were operated upon if they became symptomatic or if the aneurysm reached a size of 6 cm. In addition, the rapid enlargement of an aneurysm (greater than 1 cm in a year or less) in a poor risk patient was considered an indication for surgery.

Preoperative routine. All elective aneurysm patients were subjected to treadmill coronary stress testing and cardiologic consultation. A positive stress test was an indication for coronary angiography, and angiographic evidence of severe coronary disease such as greater than 90% stenosis of the left main, right main, or left anterior descending coronary arteries, even if asymptomatic, was considered an indication for preliminary coronary bypass. In addition, a noninvasive carotid duplex scan was performed on any patient in whom there was a history of a cerebrovascular event or evidence of a carotid bruit. Stenoses greater than 80% by diameter were treated by staged carotid endarterectomy. During the past year, patients were informed about and encouraged to participate in an autologous blood donation program in which 1 or 2 units of blood were donated during the 2 weeks prior to admission for aneurysmectomy. A minimum period of 6 days was required between the last blood donation and admission for elective surgery.

On the day of admission all patients were subjected to formal contrast aortography to define the status of their renal and visceral vessels, the proximal extent of aneurysms suspicious for suprarenal involvement, and the extent of distal iliac disease. A Swan-Ganz catheter was placed and the patient transferred to the intensive care unit for hydration and cardiac monitoring the evening before surgery.

Current operative routine. All patients were monitored with both an intra-arterial line and the Swan-Ganz catheter. Cefazolin was administered to all patients preoperatively. In addition, more recently intrathecal morphine was injected just after anesthetic induction to minimize postoperative pain. The abdominal wall was prepared with Betadine and covered with a Vi-drape. All patients were operated on through a vertical midline transperitoneal incision. The Gomez self-retaining retractor greatly facilitated exposure of the aneurysm and virtually eliminated the need for a second assistant. Proximal dissection was minimized and limited to the area of the neck of the aneurysm. Further dissection usually was limited to the common iliac vessels. The patient was systemically administered heparin 5000 U I.V. Occlusion of the common iliac arteries was generally performed first to prevent atheromatous embolization, followed by proximal aortic clamping with Wylie hypogastric artery clamps, which offer little interference to the operating surgeon. Preclotted knitted Dacron prostheses were used routinely. The Hemonetics Cell Saver (Haemonetics Corp., Braintree, MA) was utilized during the last 3 years on all elective cases. Tube grafts were placed for reconstruction whenever possible. Prolene was used for all vascular anastomoses. Following coverage of the Dacron graft by a retroperitoneal closure in two layers, the area of dissection and graft implantation was irrigated with a Kanamycin and Bacitracin solution.

Details of the special operative techniques required to deal with simultaneous suprarenal extension, hypogastric aneurysms, horseshoe kidney, accessory renal arteries, renal stenosis, mesenteric vascular insufficiency, inflammatory aneurysms, and other complications are beyond the scope of this article, but we have followed conventionally accepted approaches to these situations.

Postoperative routine care included 3 to 4 days in the intensive care unit. Fiberoptic bronchoscopy was used

TABLE 1. *Preoperative Risk Facors*

Smoker	82.9
Hypertension	45.1
Prior myocardial infarction	19.7
Prior stroke	4.9
Diabetes	8.1
Respiratory insufficiency ($FEV_1 < 2$)	20.5
Renal insufficiency (Cr > 1.5)	12.2

Values are given as percentages.

liberally for atelectasis or retained bronchial secretions. The Swan-Ganz catheter and arterial line were generally removed on the first or second postoperative day as was the Foley catheter. The nasogastric tube was retained until full evidence of intestinal function was present. Prolonged nasal oxygen was monitored by room air blood gas analyses and usually used for 5 to 6 days. Prolonged hospital stays averaging 10 days were routine. Following discharge, all patients were entered in the Vascular Registry, and follow-up was requested at 1, 3, 6, and 12 months and then on an annual basis.

Patient Demographic and Risk Factors

One-hundred twenty-three patients were operated on during the review period; 102 (82.9%) were males and the mean age was 71.4 years (range; 46–93 yr); 102 of the patients were smokers (82.9%).

Pertinent risk factors are summarized in Table 1, and include hypertension in 54.9% and severe respiratory, cardiac, and/or renal disease in 18–21%. Seven patients (5.7%) had been subjected to prior coronary artery bypass; 6 (4.9%) had a previous history of stroke; and 5 had prior carotid endarterectomy (4.1%). Conditions requiring additional or modified surgery included inflammatory aneurysm (1), severe renal artery stenosis causing hypertension (1), horseshoe kidney (2), and inferior mesenteric artery reimplantation (1). None of the aneurysms extended above the renal arteries, requiring suprarenal resection.

Operative Factors

Mean aneurysm size at the time of surgery was 5.8 cm (range; 3–11). Anesthetic time averaged 3.5 hours (range: 2–6.3) and mean operative time was 2.4 hours (range: 1–5). Aortic cross-clamp time averaged 48 minutes. Tube grafts were employed in 50% of the patients and bifurcation grafts in the remainder. There was no difference in the mean aneurysm size between those in whom bifurcation grafts were necessary or where tube grafts could be used (Table 2). However, cross-clamp time was decreased from 52 to 40 minutes when tube grafts were inserted ($p < 0.001$). In addition, mean operating time was decreased from 2.5 to 2.2 hours.

TABLE 2. *Abdominal Aortic Aneurysm: Graft Type*

	Graft Type	
	Bifurcation	Tube
Aneurysm size (cm)	5.7 ± 1.3	5.9 ± 1.4
Cross-clamp time (min)	52	40 ($p < 0.001$)
Operating time (h)	2.5	2.2
Blood loss (mL)	1202	1288
N	61	61

TABLE 3. *Abdominal Aortic Aneurysm: Operative Morbidity Rates*

System	N
Cardiac	1
Pulmonary	4
Renal-GU	5
Peripheral vascular	3
DVT-PE	4
Gastrointestinal	2
Wound (superficial infections)	2
Sepsis (septicemia)	1
Retroperitoneal hematoma	1

Cell saver. Seventy-five patients were operated on prior to the initiation of routine cell saver use with an average blood loss of 1582 mL, and an average replacement of 4.1 U of bank blood. Since institution of the use of the cell saver on a routine basis, 47 additional patients have been operated on with a mean blood loss of 1087 mL and an average return of 3.2 U of cell saver blood (560 mL), which decreased the requirement for bank blood from 4.1 to 2.0 U.

Operative mortality and morbidity rates. There was one operative death within the hospital or 30-day postoperative course in the 123 consecutive patients in this series (0.8%). Operative morbidity rate is summarized in Table 3 and indicates a predominance of pulmonary, renal, peripheral vascular, and thromboembolic problems. Only one cardiac complication occurred (myocardial infarction), and there were no associated strokes. An analysis of morbidity rates by age group indicated only a modest increase after the age of 65.

Survival. The overall life-table probability of survival for all patients in this series at 5 years was 72%, including the operative mortality. For those patients who were hypertensive it was 73%. Patients with a prior history of myocardial infarction had a significantly reduced probability of 5-year survival at 51%, in contrast to those with a prior coronary artery bypass procedure who had a 100% likelihood of 5-year survival.

For the fifty-six patients less than 70 years of age the probability of surviving 5 years was 79%. For those between 70 and 79 years of age (N = 47) the probability of surviving 5 years was 67% and for those patients 80 years or older (N = 20) the probability was 66%. The comparative 5-year survival probability between those over and under 70 years of age is documented in Figure 1 and Table 4, and shows essentially no difference for

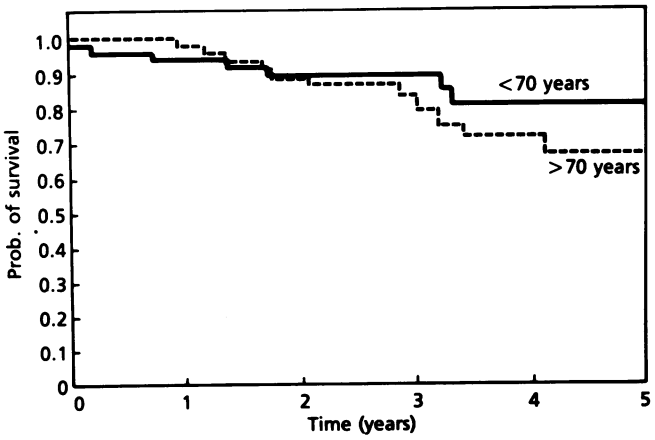

FIG. 1. Life-table analysis of survival following elective abdominal aortic aneurysm surgery.

the first 3 years and no significant difference at 5 years. Table 5 compares the current series with the recently published data of Crawford et al.[5] and of Hollier et al.[10] In all of these studies, the elective operative mortality rate for aneurysm surgery is in the range of 2% or less, and the likelihood of surviving 5 years following surgery is approaching that of the general population, which is 80% for an age- and sex-adjusted group. Most significant, however, is the increase in survival for the patient group over the age of 70. The report by Crawford et al.,[5] which includes Crawford's entire 25-year experience, includes patients treated in a much earlier era, with a 43% probability of 5-year survival for patients over 70, which must be regarded as representative of very good results during the time span reported. This impression is also confirmed by the data of Johnson et al.,[7] which includes the time span since 1952. However, the recent Mayo Clinic publications,[3,4,10] as well as our own, indicate a substantial increase in the likelihood of survival for those patients over 70, which closely approaches the survival of the general population with a similar age and sex distribution.

TABLE 5. *Abdominal Aortic aneurysm: Life Expectancy after Resection*

Author	Crawford (Baylor)	Hollier (Mayo)	Scripps Clinic
Year	1981	1984	1986
No. of patients	920	1112	123
Operative mortality rate (%)	1.9	2.6	0.8
5-year life expectancy (%)*	63	68	72
Age			
<60 yr	71	76	79
60–70 yr	66	71	
>70 yr	43	60	66

* General population (age- and sex-adjusted) = 80%.

Discussion

Improvement in the care of patients with abdominal aortic aneurysms during the 35 years since the first replacement procedures were introduced has been based on progress in the following areas:

1. *Early diagnosis.* Increased suspicion, and the ready availability of relatively inexpensive and extremely accurate noninvasive methods have permitted diagnosis at an earlier stage since the introduction of ultrasound in 1970 and CT scanning in 1980.[1,2] Both modalities are essentially 100% sensitive in the detection and accurate diagnosis of the disease, and are within 2–3 mm of operative size estimates. Thus, 80% of the aneurysms detected in the extensive UCSD series[2] during the past 15 years were 6 cm or less. Therefore, the clinician

TABLE 4. *Life-table Analysis of Survival Following Abdominal Aortic Aneurysm Surgery*

Months Postsurgery	No. of Patients Entering	Number Withdrawn	Number at Risk	Number of Deaths	Proportion Surviving	Cumulative Proportion Surviving
Patients under 70 years of age (N = 60)						
0–12	60	11	49	2	0.956	0.956
13–24	47	10	37	2	0.946	0.907
25–36	35	11	24	0	1.0	0.907
37–48	24	5	19	2	0.89474	0.812
49–60	17	9	8	0	1.0	0.812
61–72	8	1	7	0	1.0	0.812
73–84	7	4	3	0	1.0	0.812
85–96	3	3	0	0	—	—
Patients over 70 years of age (N = 63)						
0–12	63	16	47	0	1.0	1.0
13–24	47	2	45	5	0.889	0.889
25–36	40	15	25	2	0.92	0.818
37–48	23	5	18	3	0.833	0.681
49–60	15	4	11	1	0.909	0.620
61–72	10	7	3	0	1.0	0.620
73–84	3	2	1	0	1.0	0.620
85–96	1	1	0	0	—	—

is more frequently faced with a patient with a smaller asymptomatic aneurysm.

2. *Thorough cardiovascular evaluation.* Routine cardiac stress testing and frequent or routine cerebrovascular scanning has markedly reduced the incidence of cardiac and neurologic complications, which used to be most feared in elective aneurysm surgery. The identification of severe coronary or carotid arterial disease has become an indication for prior revascularization of these vessels. However, routine coronary angiography, as advocated by Hertzer[6] and Hertzer et al.[11] does not appear to be necessary or appropriate in this setting.

3. *Extensive preoperative preparation.* Preoperative evaluations of pulmonary function and renal disease, formal aortography, and the routine placement of a preoperative Swan-Ganz catheter permits maximizing prophylactic and early therapeutic management of potentially serious complications. We have followed the suggestions of Ruby et al.[12] and Whittemore et al.[13] throughout this series and firmly believe they have been very important adjuncts in the intraoperative and early postoperative management of many of these patients.

4. *Expeditious surgery.* The availability of the Gomez self-retaining retractor, minimizing the need for assistance and erratic retraction, routine use of the cell saver, administration of autologous blood, and minimal dissection have decreased blood loss and expedited surgery. The average operating time of 2.5 hours in an institution heavily committed to a vascular fellowship training program documents the resulting advantages in patient care. Alternative procedures, such as induced aneurysm thrombosis and peripheral bypass, as advocated by Leather et al.[14] do not seem necessary as emphasized by Schwartz et al.,[15] since the operative morbidity rate for elective resection can be decreased to under 1% despite the presence of serious multisystem compromise and advanced age in many patients.

5. *Aggressive postoperative care.* Problems of hemodynamic stability, respiratory function and renal function are pursued with vigor during the early postoperative period.

6. *Antibiotic prophylaxis.* The routine use of preoperative, intraoperative, local operative, and postoperative antibiotics appears to have minimized wound and other infectious problems. In the entire series there has been no instance of graft infection or of serious wound infection.

7. *Regular or routine postoperative follow-up.* The computerized vascular registry permits identification of patients' current status on a continuing basis. Patients who have not returned for routine follow-up visits are contacted regarding their current status in a regularized fashion. This permits periodic surveys of the late complications of surgical treatment and allows monitoring and continuing care of associated medical problems. In addition, it provides the surgeon with a continuing stream of information regarding the surgeon's own experience, problems, and late results.

Conclusions

A consecutive series of 123 patients with abdominal aortic aneurysms were subjected to elective or urgent surgery with a mortality rate of 0.8% and overall 5-year survival rate of 72%. These results attest to improvements in our ability to select patients for elective surgery and perform such procedures with a low risk rate. In addition, the earlier diagnosis of these lesions simplifies the surgical approach, permitting the use of tube grafts in 50% of the patients. No late complications of iliac aneurysm enlargement were detected in this series as a result of this policy. Elective aneurysm surgery is now capable of achieving late survival rates approaching those of the normal population despite the presence of significant concomitant cardiovascular, pulmonary, and renal disease.

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