Survival Improvement Following Aortic Aneurysm Resection

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Abdominal aortic aneurysm resections were performed on 298 patients between January, 1966 and December, 1973. The results were compared with 186 resections previously reported between 1955-1965. Hospital mortality rates for elective resections were 13% in 1955-1965, 8.4% in 1966-1973, and 4.2% in the 113 patients treated during the last 3 years. Urgent resections for intact aneurysms, previously associated with a 36% mortality, resulted in a 6% mortality rate in 1966-1973. The emergency resection mortality rate for ruptured aneurysm, originally 69%, was reduced to a present day over-all mortality of 55%, and 42% for the last 3 years. Calculated actuarial survival at 5 years was 65% for urgent (intact), 60% for elective and 40% for emergency (ruptured) groups. Atherosclerosis remains the major deterrent to long-term survival with myocardial infarction and stroke causing 43% of deaths occurring within 5 years. Improved survival appeared secondary to better operative technique, postoperative patient monitoring, increased surgical experience, and more elective resections of smaller, asymptomatic aneurysms than in 1955-1965. With present day low mortality rates, elective resection should be recommended in all patients without significant medical contraindications.

ABDOMINAL aortic aneurysmectomy became a common operation after 1952, when Dubost et al. first described a successful aortic resection and graft replacement.[12] In 1968, 186 consecutive aneurysm resections analyzed with regard to preoperative management, operative technique and surgical results were reported from this institution.[26] This report is based on a study of 298 patients who have had resections of abdominal aortic aneurysms performed by the full-time attendings and residents at the University of Rochester Medical Center between June 1966 and December 1973.

Material and Methods

Because of the marked difference between the operative mortality of intact and ruptured aneurysms, our present data, as in a previous publication, is divided into three groups: Group I, ruptured aneurysms (bleeding present in the retroperitoneum or peritoneum); Group II, intact aneurysms having urgent resection because of acute expansion, increasing pain or possibility of rupture; Group III, electively resected aneurysms.[26]

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Patients who had resection of their aneurysm with graft replacement or died during performance of the operation were included. Fifteen patients who had wiring of their aneurysm and 5 who had ligation of the aorta with insertion of axillofemoral grafts were excluded. The inclusion of these alternative methods of treatment would not significantly alter the over-all mortality rates and will be reported elsewhere.

Emergency Resection of Ruptured Aneurysm (Group I)

There were 56 patients (47 men, 9 women) in this group, ranging in age from 60-80 years (average 69-years-old). Eighty per cent of the patients had arteriosclerotic heart disease (ASHD) on the basis of documented past myocardial infarctions or a history of angina (Table 1).

If the diagnosis of ruptured abdominal aortic aneurysm was suspected clinically immediate preparations were made for transporting the patient to the operating room and all such patients were included in the study. Forty-four patients (82%) were in shock (systemic blood pressures SBP less than 90 mm Hg/60 mm Hg) prior to surgery. Preoperative preparations included introduction of large bore intravenous lines in one or both arms for volume replacement, insertion of a subclavian central venous pressure (CPV) line for monitoring, passage of an indwelling urinary catheter, insertion of a nasogastric tube, administration of antibiotics and the typing and cross matching of at least 6 units of whole blood.

After aseptic preparations of the abdomen, a long midline incision was used to enter the peritoneal cavity.

TABLE 1. *Summary of Group Data*

	Male:Female	ASHD	Age (Average)
Elective	185:40	70%	67 y/o
Urgent	13:4	59%	70 y/o
Ruptured	47:9	80%	69 y/o

There were large retroperitoneal hematomas in all patients and free intraperitoneal blood in 40%. Control of the aorta was obtained in all cases either through the gastrohepatic or gastrocolic ligaments. Another clamp was then placed in the infrarenal position as soon as feasible in order to minimize renal ischemic time. After distal control of the iliac vessels, the aneurysm was opened and bleeding lumbar arteries were oversewn. No aneurysms were completely resected and woven Dacron bifurcation grafts were used for reconstruction with distal anastomoses made to the common iliac or external iliac arteries in 70% of the patients and to the common femoral arteries in 30% of them. Declamping hypotension was minimized by adequate blood replacement and testing of the proximal anastomosis prior to beginning the distal anastomoses. Mannitol and volume replacement were used if prolonged supra-renal cross-clamping was necessary or diminished urinary output was evident.

No intra-operative deaths during resection were excluded from this series.

Postoperatively all patients were admitted to the surgical intensive care unit where monitoring of systemic blood pressure, CVP, urinary output, abdominal girth, peripheral pulses and hematocrit were carried out.

Urgent Resections of Intact Aneurysms (Group II)

There were 17 patients presenting with increasingly severe symptoms of suspected aortic aneurysm expansion or rupture. There were 13 men and 4 women with an average age of 70 years. Fifty-nine per cent had ASHD (Table 1). No preoperative hypotension, anuria, or acute electrocardiographic (ECG) changes were present in these patients. Operation was scheduled as an urgent procedure after preoperative preparations were completed. Infrarenal aortic control was most often attained initially, systemic heparinization was always used, and pre-clotted knitted, rather than woven, Dacron prostheses were frequently employed. There was no evidence of retroperitoneal blood but intramural fresh hematomas were present in 24% of the patients. No aneurysms were completely resected and distal anastomoses were made to the distal aorta in 12%, common iliac and external iliac arteries in 78% and common femoral arteries in 10% of the patients. The grafts were wrapped with the residual sac and the peritoneum was closed carefully to avoid the duodenum and superior mesenteric vein.

TABLE 2. *Hospital Mortality for Aneurysm Resection (1966-73)*

Classification	# Pts	Deaths	% Hosp. Mortality
Ruptured	56	31	55
Urgent	17	1	6
Elective	225	19	8.4

Elective Aneurysm Resection (Group III)

There were 225 patients (185 men and 40 women) with an average age of 67 years, who underwent elective aneurysm resection. Seventy per cent had ASHD (Table 1). Routine preoperative evaluation and preparation for surgery were carried out as previously described. In 37% of cases, the aneurysm was totally resected, while in the remainder the pre-clotted knitted Dacron or woven grafts were covered with the residual sac and peritoneum. Distal anastomoses were made as follows: distal aorta (10%), common iliac and external iliac arteries (74%), common femoral arteries (16%). Additional procedures after aneurysm resection and reperitonealization included: one cholecystectomy, one colectomy, one inguinal herniorrhaphy, three tracheostomies, two gastrostomies, one renal artery reconstruction, and one bilateral nephrectomy.

Results

Group I

Fifty-five per cent of these 56 patients died in the hospital or within 30 days of operation during the period 1966-1973 (Table 2). The mortality rate was 42% during the period of 1971-1973. Free intra-abdominal bleeding, present in 40% of the patients, was associated with a 57% mortality rate, while patients with contained ruptures had a 48% mortality rate. Arteriosclerotic heart disease (ASHD) was not a significant determinant of operative survival. There was a 26% mortality rate in patients with pre-existing ASHD contrasted to a 66% rate in patients without ASHD. Preoperative shock was associated with a 67% mortality rate as compared to a 25% mortality rate in patients without shock. Advancing age resulted in a linear increase in mortality rate from 33% in the 50-59 year age group to 100% in those over 80 years old (Table 3).

Postoperative complications occurred in 84% of the patients (Table 4). Renal failure (70% mortality rate), myocardial infarction (100% mortality rate) and bleeding were the major causes of postoperative death. Pulmonary insufficiency occurred in 2 patients without mortality.

The actuarial survival rates indicate that 31 patients died intra-operatively or within 30 days, and 2 additional patients died within 1 year (Table 5) (Fig. 1). Thereafter, no deaths occurred in the at-risk group for 5 years.

Group II

The hospital mortality for 17 patients was 6% for 1966-1973 (Table 2). ASHD was present in 60% of the patients and was associated with a 9% mortality rate, as

TABLE 3. *Operative Mortality–Age Related*

Group	# Pts Age 50-59	Mortality Rate (%)	# Pts Age 60-69	Mortality Rate (%)	# Pts Age 70-79	Mortality Rate (%)	# Pts Age 80-	Mortality Rate (%)
Elective & Urgent	42	0	95	6	95	13	14	7
Ruptured	9	33	20	35	23	74	4	100

compared to 0% in those without ASHD. An actuarial survival curve paralleled the elective group curve with a 65% 5-year survival (Fig. 1). Late deaths were caused by myocardial infarction (2 patients), aspiration pneumonia (1 patient), and pulmonary embolus (1 patient) (Table 5).

Group III

The hospital mortality rate was 8.4% in 1966-1973 and 4.2% for 1971-1973 (Table 2 and Fig. 2). Pre-existing ASHD was associated with a 9% operative mortality rate while no hospital deaths occurred in patients without ASHD. The mortality rate in the 80 plus age group was similar to the 60-69 year olds (Table 3). There was a 13% mortality rate for the 70-79 year old age group, but this group was heavily weighted by patients operated upon early in the series with 70% incidence of ASHD.

Postoperative complications were present in 40% of the patients (Table 4). Myocardial infarction (10 deaths), and renal failure requiring dialysis (4 deaths) comprised the most frequent fatal complications. Operative site bleeding required re-exploration of 15 patients with three mortalities. Pulmonary insufficiency complicated by pneumonia resulted in a 33% mortality in 6 patients and peripheral embolism requiring removal by Fogarty catheters occurred in 6 patients with the loss of one limb and no associated deaths. No patient survived a post-operative cerebrovascular accident (CVA) (3 deaths), and 6 graft infections resulted in 1 death.

Actuarial analysis revealed a 60% five-year survival (Fig. 1). Myocardial infarction and strokes caused 41% and 2% of late deaths respectively and carcinoma, 23% (Table 5). The cause of 25% of the late deaths was not known.

TABLE 4. *Postoperative complication*

Complications	Ruptured # Pts	Ruptured # Deaths	Elective & Urgent # Pts	Elective & Urgent # Deaths
None	9	0	151	0
Renal failure	10	7	9	4
Myocardial infarction	13	13	16	10
Bleeding-operative site gastrointestinal	9	6	15	3
	5	2	2	0
Stroke	1	1	3	3
Pulmonary insufficiency	2	0	6	2
Pulmonary emboli	2	1	3	0
Graft infection	3	2	6	1
Venous thrombosis	6	0	0	0
Peripheral embolism	2	0	6	0
Small bowel obstruction	1	0	4	0
Arrhythmias	4	1	23	2

Discussion

What is the expected mortality rate for resection of abdominal aortic aneurysms? In order to answer this question, reported series of aneurysm resections from 1955 to the present were reviewed and representative series of different sizes were combined to obtain a good group of mortality rates for aneurysm operations. This method can be criticized on the basis of differing patient populations, surgical techniques, experience of operators, size of aneurysms and degree of atherosclerosis, yet it represents one method of establishing the mortality rates of procedures done by independent surgeons during a concurrent period (Tables 6-9).

The group hospital mortality rates for ruptured abdominal aortic aneurysms prior to 1966 was 53% for 765 patients (Table 6). Two series overlapped, but the number of patients involved, 72, was not significant. In comparison, since 1966, 11 series with 372 patients had an average group mortality rate of 45%. There was an overlap from pre-1966 present in 5 series, thus representing a high estimation of average mortality rate (Table 7). Improvement in the results of ruptured aneurysm treat-

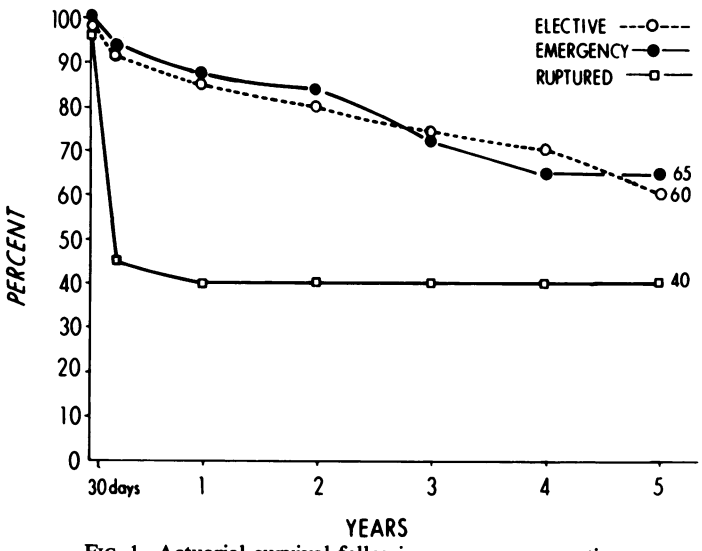

FIG. 1. Actuarial survival following aneurysm resection.

TABLE 5. *Causes of Late Deaths in Hospital Survivors*

Cause of Death	Ruptured Aneurysms # Pts	Ruptured Aneurysms Late Death (%)	Intact Aneurysms Urgent # Pts	Intact Aneurysms Urgent Late Death (%)	Intact Aneurysms Elective # Pts	Intact Aneurysms Elective Late Death (%)
Myocardial infarction			2	50%	18	41%
Cancer (lung, pancreas ovary, bladder)	1	50%			10	23%
Stroke					1	2%
Infected graft with anast. breakdown					2	5%
Infected graft with sepsis					1	2%
Pulmonary embolus			1	25%		
Unknown	1	50%			11	25%
Pancreatitis					1	2%
Pneumonia (aspiration)				25%		

ment appears to be limited by the basic lethality of the lesion. Shock, preoperative oliguria, and delay of diagnosis have all been cited as major deterrants to operative survival. Our personal series reveals a mortality rate of 55% since 1965 and 42% from 1971-1973. In comparison with the previous report from this institution, an analysis reveals that fewer patients from the current series died from preoperative shock (67% vs 77%) and fewer developed postoperative renal dysfunction (18% vs 30%).[26] ASHD made no difference in operative survival in the current series as in the previous series.[26]

Four series included an urgent intact operative group for comparison.[5, 26, 31, 33] (Table 8). Other reports included urgent intact and ruptured aneurysms together with expectedly lower mortality figures and these were not included in our tabulations. In the accumulated group of 135 patients, the group mortality prior to 1966 was 26%, well below that of the ruptured group, but significantly higher than the elective mortality rate for that period. Since 1966, the mortality rate has dropped to 5.4%, closely paralleling elective operations (5.2%) (Table 9). These figures represent the strongest argument for aggressiveness in the treatment of abdominal aortic aneurysm, especially when symptoms are present.

The group mortality rate for elective resections of aneurysms was 10.5% in the pre-1966 series, and 5.2% post-1966, emphasizing a downward trend in mortality rate with experience (Tables 8 and 9). The latter figure is a high estimate because of pre-1966 overlap in 5 series. Our mortality rate has improved steadily from 21.9% in 1955-1960 to 4.2% in 1971-1973 (Fig. 2). This is due to a combination of factors which deserve mention. Patient selection has changed somewhat; patients with smaller or asymptomatic aneurysms currently are electively resected more often. Operations for smaller aneurysms proba-

TABLE 6. *Cumulative Reported Series–Ruptured Aneurysms (Through 1966)*

Year of Report	authors	Period	No. Patients	Hosp. Mortality (%)
1959	Sheranian et al.[29]	53-57	6	50
1961	Gryska et al.[18]	57-60	25	58
1961	MacVaugh and Roberts[24]	53-60	26	85
1963	Vasko et al.[6]	-63	34	74
1963	Voorhees and McAllister[35]	-63	34	76
1964	DeBakey et al.[7]	-64	276	34
1964	Mannick et al.[25]	-64	25	32
1966	Szilagyi et al.[31]	52-65	78	60
1967	Kouchoukos et al.[21]	58-66	36	61
1968	May et al.[26]	58-65	41	69
1969	Dodenhoff and Cox[11]	57-66	37	86
1970	Van Heeckeren[33]	56-63	31	58
1970	Alpert and Parsonnet*[1]	61-68	40	69
1970	Gardner et al.[17]	64-65	8	88
1972	Williams et al.[36]	62-68	32	65
1973	Stokes and Butcher[30]	58-66	36	61
	Total		765	53%

*Patient included past 1966, no yearly breakdown present.

TABLE 7. *Cumulative Reported Series–Ruptured Aortic Aneurysms (Recent)*

Year of Report	Authors	Period	No. Patients	Hosp. Mortality (%)
1970	Van Heeckeren[33]	64-69	26	62
1970	Gardner et al.[17]	66-68	16	37
1970	Darling[6]	61-68	60	40
1972	Williams et al.[36]	68-71	46	34
1972	Yashar et al.[38]	58-70	32	56
1972	Lagaaij et al.[22]	58-70	100	38
1972	Szilagyi et al.[32]	66-70	?	43
1973	Stokes and Butcher[30]	65-71	13	15
1973	Key and Sokol[20]	66-72	49	43
1973	Rainer et al.[27]	-73	12	17
Present series		66-73	56	55
		Total	372 Group Mort.	45

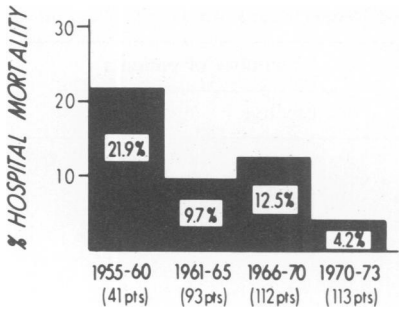

FIG. 2. Mortality rate for elective aneurysm resection.

bly carry a lower mortality rate.[31] The average age for the pre- and post-1966 series was similar (67 years). The current series had more patients with ASHD (70% vs 55%) and more in-hospital mortalities due to cardiac failure. (52% vs 17%).

The hospital survival of patients following abdominal aortic aneurysm resections has steadily improved since the early 1950's. Darling, in 1970, noting a 4% mortality rate, indicated that with few exceptions, all patients with a palpable aneurysm should have a resection.[6] Szilagyi listed the following contraindications: 1) history of an MI within 3 months; 2) intractible congestive heart failure; 3) intractible angina; 4) severe pulmonary disease; 5) incapacitating residuals from CVAs; 6) renal function impairment with a creatinine greater than 3.0 mgm/100 ml; 7) associated lethal disease with less than 3 year survival expectation; 8) asymptomatic less than 6 cm size aneurysms in a patient over 75 years of age.[31] Our previous series encouraged an aggressive approach noting that renal disease, severe ASHD, or pulmonary disease should be relative contraindications to elective resection. However, with any change in the baseline status, such as increasing pain, or size, gratifying results were obtained with urgent resections.

Preoperative care presently includes overnight hydration with lactated Ringer's solution prior to surgery and prophylactic antibiotic coverage, a practice previously not considered routine. The role of intra-operative experience and technique may be the most significant factor in improved results. The belief that experience does improve operative results is born out by a reduction in operative mortality in all consecutive series reviewed.[6,7,20,26,32] Furthermore, 63% of posterior aneurysm walls were left intact compared with 21% in the past series with injury to the inferior vena cava or iliac veins a rare problem (1.5% of cases).

Postoperative care and increased knowledge of postoperative complications have improved the survival results. The operative mortality reduction since 1970 is coincidental with a restructuring of the intensive care unit and improved house staff coverage. (Fig. 2) Pulmonary insufficiency was recognized early with only 2 related deaths. This 0.66% mortality rate is significantly less than the 3.4% to 19% reported in other series.[5,11] Postoperative arrhytmias were frequent (10%) but death related to this problem was less than 1%. Renal failure requiring dialysis was reduced from 14% to 3.7% but the death rate of 22% was not significantly altered from the figure of 28% in our previous series.[26]

The patient population was also analyzed for long-term survival and actuarial curves calculated[13] (Fig. 1). The

TABLE 8. *Cumulative Reported Series Elective and Urgent Aneurysm Resections (Through 1966)*

Year of Report	Authors	Period	Number of Patients		Hospital Mortality (%)	
			Elective	Urgent	Elective	Urgent
1959	Sheranian et al.[29]	53-57	104		14	
1961	MacVaugh and Robert[24]	53-60	81		11	
1961	Gryska et al.[18]	53-60	124		10	
1963	Vasko et al.[34]	52-62	136		10	
1963	Voorhees and McAllister[35]	54-62	169		18	
1963	Cannon et al.[4]	54-62	66		15	
1964	DeBakey et al.[7]	52-62	1186		7	
		62-64	533		5	
1964	Hardin[19]	54-63	109		8	
1966	Szilagyi et al.[31]	52-65	309	92	13	21
1966	Levy et al.[23]	57-64	100		17	
1967	Bernstein et al.[3]	55-60	85		11	
1967	Friedman and Hufnagel[16]	65-66	100		4	
1968	May et al.[26]	55-65	146	11	15	33
1969	Foster et al.[15]	54-65	116		18	
1970	Couch et al.[5]	59-66		9		18
1970	van Heeckeren[33]	56-63		23		39
	Total		3604	135 Grp. Mort.	10.5%	26%

TABLE 9. *Cumulative Reported Series–Elective and Urgent Aortic Aneurysm Resection (Recent)*

Year of Report	Authors	Period	Number of patients		Hospital Mortality (%)	
			Elective	Urgent	Elective	Urgent
1970	Alpert and Parsonnet[1]	61-68	100		2	
1970	Darling[6]	61-70	155		2.6	
1970	Baker and Roberts[2]	6 -69	145		2.7	
1970	van Heeckeren[33]	64-69	34	22	12	5
1970	Gardner et al.[17]	66-68	39		8	
1972	Williams et al.[36]	68-71	66		7.4	
1972	Yashar et al.[38]	58-70	105		5.6	
1972	Szilagyi et al.[32]	58-70	70		7	0.2
1972	Lagaaij et al.[22]	58-70	300		6	
1973	Key and Sokol[20]	66-72	82		0	
1973	Stokes and Butcher[30]	65-71	87		4	
Present series		66-73	225	17	8.4	6
	Total		1408	39 Grp. Mort.	5.2	5.4

actuarial method used to compute survival is considered reliable. It includes all patients who survived, died, were lost to followup, removed, or at risk during a given interval. It encompasses operative and hospital mortality and accurately reflects time-related survival in a large group of patients.[13] Using this method, 5-year survival in the elective—urgent group was 60-65%, and 40% in the ruptured group. No patient died in the ruptured group after one year, with the initial loss primarily due to a hospital mortality rate of 55%. The elective and urgent intact group had parallel curves with a yearly mortality rate between 4-7%. This agrees with reports of DeBakey,[7] Szilagyi,[31] and Key.[20]

Ability to demonstrate an improved survival in the electively resected group requires comparison with a base-line mortality rate for the non-operated aneurysm group. Estes reported unoperated aneurysms had an 18% 5-year survival with a 66% incidence of rupture.[14] In later reports by Szilagyi, the non-operated group had a 16% and 22% survival.[31,32] However, reports by Schatz et al. and Wolfe estimate this 5-year survival at 30-40% with a 44% incidence of rupture.[28,37] The Estes series was criticized for the high percentage of large pulsatile aneurysms, inclusion of ruptured aneurysms, and significant number of patients lost to followup. The experience of Schatz et al. does not include reasons for individual patient exclusion and has a high incidence of small (less than 7 cm) asymptomatic aneurysms (74%) representing a low-risk group. However, despite which survival figure (18% or 30-40%) is representative, the 60-65% 5-year survival in our series and others demonstrates a definite superiority of the surgically-treated group.[7,31]

Late deaths in the elective group are primarily related to other manifestations of atherosclerosis (Table 5). The major cause of death was myocardial infarction in 41%, cancer in 23% and stroke in 2% of patients. Similar results are seen in other areas of peripheral vascular disease. A group of patients who underwent carotid endarterectomies had a 66% 5-year survival rate, while those undergoing femoralpopliteal bypass grafting had a 52% 5-year survival.[9,10] Late deaths in both groups were secondary to MIs and stroke in 30-35% of patients followed for 5-years.

The present series demonstrates a significant decrease in operative mortality rates and improved long-term survival of patients following aortic aneurysm resection. With experience and knowledge at its current level, patients with ruptured aneurysms now have a 55% chance of recovering. Those patients undergoing elective resections have less than a 7% mortality rate. Patients having urgent resections for increasingly symptomatic palpable aneurysms have a mortality rate similar to the elective group, and it is recommended that elective aneurysm resection be carried out on all patients who do not have significant medical contraindications.

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