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The mortality of abdominal aortic aneurysm

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Summary

During a five year period 153 patients presented with abdominal aortic aneurysms and 135 received grafts. The mortality was 4.2% (3 of 71) for elective cases, 16.7% (2 of 12) for acute cases (the preoperative diagnosis of rupture found to be incorrect) and 55.8% (29 of 52) for patients with ruptured aneurysms. For patients with ruptured aneurysms there was a trend towards larger amounts of blood and colloid infusion in patients who died compared with those who survived, but there was no statistically significant difference either for the amount transfused, or for age, distance of referral, preoperative blood pressure, operating theatre time, or seniority of operating surgeon, between the two groups.

It is possible that increased attention to cardiac and renal disease might reduce mortality following elective surgery. Measures to reduce the high mortality from ruptured aneurysm must be early detection and treatment of intact aneurysms, rapid diagnosis of rupture and expeditious surgery with minimal blood loss and the accurate exclusion of rupture in acute cases to achieve the same mortality as elective surgery.

Introduction

Since the first successful graft for abdominal aortic aneurysm *(1)* advances in surgical technique, anaesthesia and intensive care have reduced the risks of elective surgery *(2–4)*. Even patients with significant medical problems can be considered for surgical reconstruction to avert aneurysm rupture *(4)*. Nevertheless, at least one third of patients in most studies present only after rupture has occurred *(3,5–7)*. Although some groups report impressively low mortality figures in these cases *(4,8,9)* most centres which receive unselected cases of rupture have a 40–60% hospital mortality *(6,7,10–13)*. A third important group of patients with aneurysms undergo emergency surgery because of the diagnosis of rupture which is not confirmed at operation. Despite the absence of leakage the mortality of these acute cases is two to three times greater than that of patients treated electively *(7,13)*.

We were disturbed by a number of deaths which occurred on our unit after aneurysm surgery. For this reason we reviewed our experience of patients presenting with abdominal aortic aneurysms over a five year period paying particular attention to possible factors contributing to mortality.

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Patients and methods

During the five years 1st July 1979–30th June 1984, 153 patients with abdominal aortic aneurysms were referred to the Peripheral Vascular Unit of the John Radcliffe Hospital, Oxford. Grafting was performed on 135 patients—71 as elective cases (62 men and 9 women), 12 acutely (9 men and 3 women), and 52 ruptured (49 men and 3 women). The ages of the three groups of patients were—elective,

TABLE I *Patients presenting with abdominal aortic aneurysms in whom grafting was not performed*

Patient	*Age*	*Presentation of aneurysm*	*Reason for no graft*
RT	57	Elective	Died from aneurysm rupture just before admission for elective surgery: diagnosis 18 days before
SG	59	Elective	Inflammatory aneurysm considered inoperable at laparotomy. Chronic renal failure
WL	72	Elective	Referred when terminally ill with penumonia
VI	72	Elective	Patient declined surgery
TW	76	Elective	Small aneurysm (5.5 cm). Ischaemic heart disease, obstructive airways disease
TT	76	Elective	Ischaemic heart disease
AS	81	Elective	Dementia, alcoholic liver disease, bronchitis, cerebrovascular accident
BB	81	Elective	Small aneurysm (5.8 cm), not enlarging
FG	72	Ruptured	Obstructive airways disease, emphysema, cor pulmonale
AH	74	Ruptured	Cerebrovascular disease. Terminally ill
DJ	74	Ruptured	Thoracoabdominal aneurysm. Cerebrovascular disease, chronic lung disease
JB	75	Ruptured	Emphysema. Hypertension
AS	76	Ruptured	Cerebrovascular accidents, ulcerative colitis
ES	78	Ruptured	Brainstem cerebrovascular accident
RA	80	Ruptured	Obstructive airways disease, cardiac failure
WF	82	Ruptured	Alcoholism, anaemia, malnourishment, obstructive airways disease, diabetes mellitus
MJ	91	Ruptured	Advanced age and shocked.

median 69 years (range 40–80), mean 67 years (s.d.±8.1): acute, median 71 years (range 53–83), mean 71 years (s.d.±8.6): ruptured, median 75 years (range 52–86), mean 71 years (s.d.±7.4). Seventeen patients were considered unsuitable for grafting and clinical details of these patients are shown in Table 1.

The numbers and causes of deaths in hospital were obtained for each group of patients by review of the case notes. Those who died following operation for ruptured aneurysms were compared with survivors with respect to the following factors which might have influenced mortality:

Age (Mann Whitney U test) In addition to medians and ranges, means and standard deviations are quoted throughout to allow comparison with other reports.

Distance from hospital Either place of residence or recorded place of collapse—greater or less than 10 miles, and also greater or less than 20 miles—were each compared by chi squared analysis.

Pre-operative systolic blood pressure Using 100 mm Hg as the threshold level (chi squared analysis).

Operating theatre time This was derived from the anaesthetic records which did not always indicate clearly the time of the incision or the end of the operative procedure. When there was any doubt the total duration of the anaesthetic record was used.

Volume of transfusion The amounts of blood, and of total colloid (blood plus Haemacel® plus plasma protein fraction) given up to the end of the anaesthetic record were compared using a Mann Whitney U test.

The presence or absence of a consultant at the operation Whether as the operating surgeon or as assistant to the vascular lecturer (senior registrar) (χ^2 analysis).

The details of postoperative complications and the duration of hospital stay were recorded for each patient.

Results

MORTALITY

Elective cases Three of 71 patients died in hospital following elective surgery, a mortality of 4.2%.

Case 1 A man aged 72 years who suffered from angina and had a history of two myocardial infarctions. He had left ventricular decompensation and also some renal impairment (urea 22.1 mmol/l and creatinine 179 mmol/l). Operation was performed because his aneurysm had become painful. Apart from transient hypotension on induction of anaesthesia he had an uneventful operation and initial recovery, but suffered a sudden cardiac arrest (ventricular fibrillation) three days after operation and resuscitation was unsuccessful.

Case 2 A man aged 64 received an aortobifemoral graft at a long (6.5 h) and technically difficult operation. Following this he showed signs of small emboli to the feet and during a prolonged convalescence developed a deep venous thrombosis. He died suddenly 77 days after operation, and autopsy examination was refused.

Case 3 A man aged 77 who had a long and difficult operation (7.5 h). His large juxtarenal aneurysm was entered posteriorly during dissection near its neck and a period of suprarenal aortic clamping was required. He subsequently required re-exploration for bleeding and received a total of 19 units of blood. Postoperatively he developed renal failure (pre-operative urea 14.9 mmol/l), and signs of cerebral damage. He died seven days after operation.

Acute cases Two of 12 (16.7%) patients who were operated on acutely died while in hospital.

Case 4 A man of 74 with a known aortic aneurysm had been denied surgery five months previously, initially because he had a carcinoma of the rectum requiring an anterior resection, and then because of his stormy postoperative course and his 'poor physical condition'; hypertension, atrial fibrillation, and mild renal dysfunction, urea 9.9 mmol/l and creatinine 115 mmol/l. He presented with a two day history of pain from his aneurysm and a Dacron® tube graft was inserted. The only operative problem was an episode of hypertension on induction of anaesthesia. He was stable for 24 hours after surgery but then required increasing therapeutic support to maintain his blood pressure and urine output. Following the sudden development of severe cardiac failure on the fourth postoperative day he developed ventricular fibrillation and died.

Case 5 A man aged 82 with an aneurysm documented for six years was admitted with 12 hours of pain. He was receiving treatment for hypertension, (admission blood pressure 295/160), had carotid, aortic, and femoral bruits, evidence of renal impairment, (urea 21.5 mmol/l), and a history of a cerebro-vascular accident causing monocular blindness. An aortic bifurcation graft was inserted, the procedure being prolonged (3.7 h) by the need for a profunda endarterectomy. Postoperatively he developed progressive cardiac and renal failure and died four days later.

Ruptured aneurysms The hospital mortality for patients with ruptured aneurysms was 29 of 52 (55.8%). The causes and times of death for these patients are shown in Table II.

OPERATION FOR RUPTURED ANEURYSM: FACTORS INFLUENCING SURVIVAL

Age There was no significant difference between the ages of survivors (range 59 to 80, median 71 years, mean 71 s.d.±5.9 years), and those who died, (range 52 to 86, median 74 years, mean 71 s.d.±8.6 years).

TABLE II *Causes of death following operations for ruptured aneurysm*

Patient	*Age*	*Causes of death*	*Time after operation (days)*
CW	52	Died on table: no more details available	0
TC	55	Acute gastric erosions: massive GI bleed	2
DS	57	Renal failure	9
AS	59	Ischaemic colitis with performation. Shock lung. Renal failure	15
LC	59	Ischaemic colitis with perforation	25
JC	63	Renal failure. Pleural effusions	22
BP	64	Rupture of thoracic aneurysm	14
RB	65	Cardiac, pulmonary and renal failure. (inflammatory aneurysm)	5
RJ	68	Bleeding: coagulation failure	<1
CS	70	Recent myocardial infarct. Ventricular fibrillation	<1
AP	71	Renal failure	8
AR	71	Renal failure	10
FL	72	Cardiac failure. Renal failure	10
WL	73	Renal failure	6
FC	74	Cardiac failure	1
JL	74	Sudden cardiac arrest	12
RN	74	Renal failure	7
WM	74	Renal failure. Myocardial infarction	10
JB	75	Intraperitoneal rupture. Extensive intravascular thrombosis	<1
DM	75	Pulmonary embolus	14
DA	76	Ischaemic colon. Bronchopneumonia	6
ES	77	Cardiac failure	<1
WM	78	Continued bleeding	<1
SC	78	Continued bleeding	<1
CH	78	Continued bleeding. Cardiorespiratory arrest	<1
EP	79	Cerebrovascular accident	5
FW	81	Renal failure. Bronchopneumonia	2
PJ	82	Renal failure. Cardiac arrest	3
MN	86	Aorta failed to hold sutures. Died on table	0

Distance of referral Fifteen of 30 (50%) patients from a distance of less than 10 miles died, compared with 14 of 22 (64%) of those from further afield. Twenty three of 41 (56%) referred from less than 20 miles distant died, compared with 6 of 11 (55%) from further than 20 miles. Neither of these differences in mortality was statistically significant.

Systolic blood pressure Thirty eight of 53 (72%) patients had a systolic blood pressure of less than 100 mmHg recorded before operation but the duration of hypotension could not be accurately determined in most cases. Although there was a trend towards higher mortality in hypotensive patients—23 of 38 (61%) died compared with 7 of 15 (47%) of those whose systolic blood pressure was maintained above 100 mmHg, this difference did not reach statistical significance.

Theatre time Total theatre time was similar for those who survived (1.7 to 5.3 h, median 3.2 h) and for those who died (range 1.5 to 5.0 h, median 3.4 h).

Volume of transfusion The amount of blood transfused was 2 to 16 units (median 8 units) for those who survived and 3 to 26 units (median 11 units) for those who died. There was no statistically significant difference between these two groups. There was an apparently significant difference in the total volume of colloid transfused between survivors (range 3 to 17 units, median 10 units) and those who died (range 3 to 36 units, median 13 units) $P=0.04$, but if this is corrected for the number of comparisons made in this study then the difference is no longer significant.

Grade of surgeon There was no significant difference in mortality. When a consultant surgeon was present at operation, 10 of 22 (45%) patients died, when surgery was performed by the vascular lecturer (senior registrar) without the assistance of a consultant 16 of 30 (53%) died.

POSTOPERATIVE COMPLICATIONS

These are shown in Table III. Renal failure and cardiac complications predominated in those who died. Overall, respiratory complications were commonest but the majority of affected patients survived. The one uniformly fatal complication was bowel ischaemia.

Re-exploration was required in all six elective cases with signs of bleeding, and in two of the five with peripheral ischaemia. Two others had only very minor distal emboli and the patient who died had irretrievable but serious distal embolism.

Among the miscellaneous complications there were two cases of buttock burns in patients with ruptured aneurysms caused by an operating table water blanket on which the thermostats had failed. Ischaemia due to peripheral vasoconstriction and aortic clamping predisposed to tissue damage by water circulating at about 45 °C. Both injuries occurred within the space of a few days, following which the fault was identified.

TABLE III *Complications recorded in patients undergoing surgery for abdominal aortic aneurysm*

	Elective and acute cases (n=83)		*Ruptured cases (n=52)*	
	Patients who survived (n=45)	*Patients who died (n=8)*	*Patients who survived (n=26)*	*Patients who died (n=46)*
Cardiac	3	3	2	9
Respiratory	17	0	5	5
Renal failure	0	2	2	13
Bleeding	5	1	4	8
Wound	2	0	1	0
Bowel ischaemia	0	0	0	3
Peripheral ischaemia	4	1	1	4
Venous thromboembolism	5	1	4	1
Other	9	0	7	3

HOSPITAL STAY

The median number of days spent in hospital after operation by survivors was 12 (range 7 to 28) for elective cases, 14 (range 11 to 22) for acute cases, and 17 (range 9 to 48) for patients with ruptured aneurysms.

Discussion

These results are disappointing and pose two questions. Firstly, how do our results compare with those of other units? Secondly, how might they be improved?

Many other reports on the surgery of ruptured aortic aneurysm published during the last decade reflect our own experience of a hospital mortality around 50% *(6,10–16)*. Centres with very low mortalities tend to operate on a highly selected minority of patients with aneurysmal rupture *(4,8,14)*. Their figures are not comparable to those of centres like our own where over a third of the aneurysms are operated on as emergencies for rupture *(3,5–7,10,11)*. Our own referral pattern is that of a district general hospital, in contrast to major tertiary referral centres in the United States. Even within the United Kingdom mortality figures require cautious interpretation, since some units exclude from surgical treatment a large proportion (25–58%) of patients presenting with rupture *(10,11,17)*.

The patient with a ruptured aneurysm has no chance of survival without surgical reconstruction. Therefore unless one can predict with certainty that a patient will not survive operation, then it would seem that surgery should almost invariably be offered. A number of factors have been associated with increased mortality after operation for aneurysm rupture. Delay in diagnosis *(17)* can only be reduced by an increased awareness of the condition by primary care physicians. Pre-existing cardiac *(14)* or renal disease and advanced age *(8,12,15,16)* are both risk factors, although many authors point out that age alone should not be a bar to surgery since some very elderly patients survive *(8,12)*. We found no significant difference in the ages of those who survived compared with those who died. It is interesting to note that the mean age of our patients is rather higher than that reported from many other centres *(3,4,7,13)*.

Other factors shown to influence the operative mortality reflect the magnitude of the blood loss; preoperative hypotension *(12,14,15)*, extensive peroperative bleeding *(14,16)*, and the volume of blood transfused *(8,16)*. In our study total transfusion requirements were greater in those who died than in survivors, and colloid plasma expanders formed a substantial proportion of the total volume transfused in these cases. In view of the possible relationship between the volume transfused and mortality, limiting operative blood loss is an important aim. Rapid accurate control of the aneurysm neck *(8)*, avoidance of venous injury, use of the inlay technique *(4)*, and tube rather than bifurcated grafts where possible *(3,5,6)*, all contribute to reducing overall blood loss.

A prolonged operation has been associated with increased mortality *(16)* although this was not our experience. There has been some suggestion that the seniority of the surgeon performing the operation has a bearing on survival *(12)* and that the number of aneurysm operations routinely performed by the surgeon is also a contributing factor *(18)*. We noted little difference in survival when a consultant was present, compared with the cases dealt with by the vascular lecturer (senior registrar) alone. Nevertheless this is difficult to evaluate in our unit as the consultant would be present at the beginning of the lecturer's training period of one year and later for cases that were presenting technical difficulties.

It has been suggested that distance travelled to hospital has a bearing on survival in two ways. Firstly, the long distances travelled to tertiary referral centres in the United

States may have a selective effect, such that only the fitter and more stable patients arrive for surgery *(3,8)*. Secondly, hospitals such as our own, which receive most of their patients within two or three hours of rupture may observe an increased mortality for those hypotensive and unfit patients who travel more than a few miles and arrive in very poor condition *(16)*. There was a slightly lower survival in our patients travelling more than 10 miles to hospital, but not in those travelling more than 20 miles.

It was not possible to identify before surgery those patients with a high chance of survival, and therefore we believe that most patients with a ruptured aneurysm should be considered suitable for operation. Despite the most skillful surgery a substantial proportion of these patients will continue to die, since many who survive a technically satisfactory operation in a stable cardiovascualr state subsequently develop renal or cardiac failure, which were the two commonest causes of death in our series.

Reported mortality from elective aneurysm repair varies widely from less than one % *(19)* to more than 10% *(6,10)*. The majority of units report mortalities between these extremes *(7,20,21)*, mostly below 5% for cases operated upon in recent years *(2–4,13,22)*. These figures are, however, influenced by patient selection which is not always clear from published reports. When details of patient selection are given it becomes apparent that up to one quarter are considered unfit for surgery *(6,17)*. The substantial risk of death from aneurysm rupture in patients refused elective surgery is now well documented *(17,23,24)* and there is an increasing trend to offer operation to all but the most aged and infirm *(4,17)*. This policy demands rigorous measures to ensure optimal cardiac performance *(19)*, and Diehl and colleagues *(20)* have adopted a policy of coronary artery bypass grafting as a prelude to aortic surgery in selected patients. All of our patients who died after elective surgery had pre-existing cardiac or renal disease. One patient (Case 1) was found at autopsy to have severe triple vessel coronary atheroma, and might have benefitted from prior coronary bypass grafting. Technical factors contributed to the two remaining deaths, substantial blood loss in one case, and dislodgement of embolic material to the feet with prolonged hospital stay and eventual death in the second.

Authors who report acute cases as a separate group agree that mortality is higher than that with planned elective surgery *(4,7,13)*, although the reasons for this have not been explained. Both of our patients who died had been refused elective surgery because the risks were felt to be unacceptably high. This posed a difficult dilemma when the patient returned with symptoms suggesting rupture. An advance in management of these cases would be an investigation which could rapidly and reliably exclude aneurysm rupture in doubtful cases. Fewer patients without aneurysm rupture would then need to be operated on as emergencies with inadequate preoperative medical evaluation.

The overriding requirement for decreasing mortality from aortic aneurysm is early detection. The differences in mortality between different centres are insignificant compared with the differences in survival of patients operated on electively and those dealt with as emergencies. Recognition of aneurysms before the onset of acute symptoms, therefore, has important implications, and published reports suggest that this is being more effectively achieved in the United States of America than in the United Kingdom. Abdominal aortic aneurysm is responsible for 1.3% of all deaths in men over the age of 65 in the UK *(25)*. Large aneurysms in thin patients can always be diagnosed by abdominal examination, which should therefore become as routine a part of the examination of men over the age of 60 years as recording the blood pressure is at present.

References

1 Dubost C, Allary M, Oeconomos N. Resection of an aneurysm of the abdominal aorta. Arch Surg 1952;64:405–8.
2 Hicks GL, Eastland MW, DeWeese JA, May AG, Rob CG. Survival improvement following aortic aneurysm resection. Ann Surg 1975;181:863–9.
3 Gordon-Smith IC, Taylor EW, Nicolaides AN, Golcman L, Kenyon JR, Eastcott HHG. Management of abdominal aortic aneurysm. Br J Surg 1978;65:834–8.
4 Crawford ES, Saleh SA, Babb JW, Glaeser DH, Vaccaro PS, Silvers A. Infrarenal abdominal aortic aneurysm: factors influencing survival after operation performed over a 25-year period. Ann. Surg. 1981;193:699–709.
5 Orr WMcN, Davies M. Simplified repair of abdominal aortic aneurysms using non-bifurcated (straight) inlay prostheses. Br J Surg 1974;61:847–9.
6 Makin GS. Changing fashions in the surgery of aortic aneurysms. Ann R Coll Surg Engl 1983;65:308–10.
7 Fielding JWL, Black J, Ashton F, Slaney G, Campbell DJ. Diagnosis and management of 528 abdominal aortic aneurysms. Br Med J 1981;283:355–9.
8 Lawrie GM, Morris GC, Crawford ES, Howell JF, Whisennand HH, Badami JP, Storey SS, Starr DS. Improved results of operation for ruptured abdominal aortic aneurysms. Surgery 1979;85:483–8.
9 Jenkins AMcL, Ruckley CV, Nolan B. Ruptured abdominal aortic aneurysm. Br J Surg 1985;72:322.
10 Cox R, Ware CC. Abdominal aortic aneurysms in a district general hospital. Ann R Coll Surg Engl 1981;63:177–80.
11 Marsh CH. Experiences with abdominal aortic aneurysms in a district general hospital. Ann R Coll Surg Engl 1980;62:294–6.
12 Butler MJ, Chant ADB, Webster JHH. Ruptured abdominal aortic aneurysms. Br J Surg 1978;65:839–41.
13 Soreide O, Grimsgaard C, Myhre HO, Solheim K, Trippestad A. Time and cause of death for 301 patients operated on for abdominal aortic aneurysms. Age and Ageing 1982;11:256–60.
14 Hoffman M, Avellone JC, Plecha FR, Rhodes RS, Donovan DL, Beven EG, DePalma RG, Frisch JA. Operation for ruptured abdominal aortic aneurysms: A community-wide experience. Surgery 1982;91:597–602.
15 Morris PJ, Buxton BF, Flanc C. Ruptured abdominal aortic aneurysms presenting to a general hospital. Med J Aust 1975;1:555–8.
16 Fielding JWL, Black J, Ashton F, Slaney G. Ruptured aortic aneurysms: postoperative complications and their aetiology. Br J. Surg 1984;71:487–91.
17 Walker EM, Hopkinson BR, Makin GS. Unoperated abdominal aortic aneurysm: presentation and natural history. Ann R Coll Surg Engl 1983;65:311–13.
18 Hertzer NR, Avellone JC, Farrell CJ, Plecha FR, Rhodes RS, Sharp WV, Wright GF. The risk of vascular surgery in a metropolitan community. J Vasc Surg 1984;1:13–21.
19 Whittemore AD, Clowes AW, Hechtman HB, Mannick JA. Aortic aneurysm repair: Reduced operative mortality associated with maintenance of optimal cardiac performance. Ann Surg 1980;192:414–21.
20 Diehl JT, Cali RF, Hertzer NR, Bevan EG. Complications of abdominal aortic reconstruction. Ann Surg 1983;197:49–56.
21 Thompson JE, Hollier LH, Patman RD, Persson AV. Surgical management of abdominal aortic aneurysms: Factors influencing mortality and morbidity—a 20 year experience. Ann Surg 1975;181:654–61.
22 Castleden WM, Mercer JC and the Members of the West Australian Vascular Service. Abdominal aortic aneurysms in Western Australia: descriptive epidemiology and patterns of rupture. Br J Surg 1985;72:109–12.
23 Estes J. Abdominal aortic aneurysms: a study of one hundred and two cases. Circulation 1950;2:258–4.
24 Bickerstaff LK, Hollier LH, Van Peenen HJ, Melton LJ, Pairolero PC, Cherry KJ. Abdominal aortic aneurysms: The changing natural history. J Vasc Surg 1984;1:6–12.
25 Review of the Registrar General on deaths by cause, sex and age in England and Wales 1983. Series DH2 No 10, Her Majesty's Stationery Office.