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Factors Increasing the Mortality Rate for Patients with Ruptured Abdominal Aortic Aneurysms

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The objective of this report was to analyze the current surgical results of operative treatment in patients suffering ruptured AAA (abdominal aortic aneurysms) and to define those independent predictive factors for mortality. During a period of 2 years, from January 1996 to December 1997, 144 patients operated on for ruptured AAA in 10 hospitals were included in a multicenter retrospective study. Among the collected variables concerning each patient, those with potential relation to surgical mortality were studied: gender, age, diabetes, hypertension, cardiopathy, pulmonary obstructive disease, preoperative renal dysfunction, symptomatic cerebrovascular disease, peripheral vascular disease, hematocrit on admission, preoperative hypotension <80 mmHg, loss of consciousness, cardiac arrest, aortic aneurysm location (infrarenal versus non-infrarenal), iliac involvement, aneurysm size, type of rupture, left renal vein ligature, ligature of a patent inferior mesenteric artery, place of aortic cross-clamping, type of grafting, exclusion of both hypogastric arteries, venous technical complications, associated surgery, use of cell saver, intraoperative blood loss, and postoperative complications (renal failure, sepsis, coagulopathy, cardiac complications, pulmonary complications, colon ischemia, prosthetic graft complications, and need for reoperation). Those variables with statistical significance in the univariate analysis were introduced into a multivariate logistic regression model to determine the independent predictors of death. From our results we concluded that surgery for ruptured abdominal aortic aneurysms continues to have an excessively high mortality rate. Even though some preoperative variables could be identified as predictors of mortality, an absolute mortality risk has not yet been determined and the decision to negate surgery should be individualized rather than taken on that basis only. Early diagnosis and treatment of symptomatic aneurysms would improve mortality figures and selective screening should be contemplated.

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INTRODUCTION

Despite an increase in the incidence of elective operations for abdominal aortic aneurysms (AAA) during the last three decades, the number of emergency operations performed due to rupture has not decreased, as should be expected. Simultaneously, the surgical mortality rate for elective repair of AAA has steadily improved over this period to about 5% as a consequence of better management of preoperative risk conditions and advances achieved in the field of anesthetics and in operative procedures. Over the same time span, however, surgical mortality for emergency repair has remained essentially unchanged and excessively high at around 50%. But it should be kept in mind that not all patients admitted for treatment of ruptured AAA undergo surgery and even a gloomier situation can be presumed if the deaths that occur outside the hospital are taken into account, so the true estimated mortality rate could reach 80-90%.[1,2] This extremely high operative death rate may be in part due to the fact that patient selection in cases of rupture is frequently difficult, because many patients have already suffered the consequences of hypovolemic shock before being admitted to the hospital.

With the aim of avoiding unnecessary suffering for patients and their families and enabling a better use of scarce resources in the present era of cost containment, it would be very helpful to be able to identify those patients with specific preoperative characteristics who would not benefit from surgery because of an unacceptably high mortality rate. Despite the large number of recent reports that have studied this subject the controversy remains, with some authors concluding that there are no preoperative characteristics that allow us to withhold emergency surgical repair for ruptured AAA. The objectives of the present multicenter report are to analyze the current surgical results of operative treatment in patients with ruptured AAA and to study simultaneously the independent predictors for death.

PATIENTS AND METHODS

Over a short period of 2 years, from January 1996 to December 1997, 144 patients underwent emergency operations for ruptured AAA at 10 hospitals. The records of the patients were retrospectively studied to preclude possible bias due to changes in techniques of surgical procedures. An acute ruptured AAA was defined as follows: if a patient was admitted with recent onset of abdominal pain, shock, or loss of consciousness and if, on radiological examination or during the surgical intervention, a retroperitoneal hematoma, free blood inside the peritoneal cavity, or a fistula between the aneurysm and adjacent structures was identified.

The medical charts of all patients who fulfilled the specified criteria were reviewed and data were collected retrospectively on a personal worksheet where each item had only one entry among several possibilities. For each patient, 82 variables were considered and those that could have been potentially related to surgical mortality were analyzed: gender, age, diabetes, hypertension, cardiopathy, pulmonary obstructive disease, preoperative renal dysfunction, symptomatic cerebrovascular disease, peripheral vascular disease, hematocrit on admission, preoperative hypotension (<80 mmHg), loss of consciousness, cardiac arrest, aortic aneurysm location (infrarenal versus noninfrarenal), iliac involvement, aneurysm size (≤7 cm vs. >7 cm), type of rupture (free rupture versus others), left renal vein ligature, ligature of a patent inferior mesenteric artery, place of aortic cross-clamping, type of grafting (tube versus bifurcated), exclusion of both hypogastric arteries, venous technical complications, associated surgery, use of cell saver, intraoperative blood loss, and postoperative complications (renal failure, sepsis, coagulopathy, cardiac complications, pulmonary complications, colon ischemia, prosthetic graft complications, and need for reoperation).

Data were analyzed with SPSS statistical software, and statistical significance was assumed for $p < 0.05$. For univariate statistical analysis, the unpaired Student's *t*-test, Mann-Whitney test, and chi-squared test were used. Clinically significant variables associated with death in univariate analysis were entered in separate multivariate logistic regression models to predict mortality (mortality as the dependent variable). Three multivariate models were constructed to analyze mortality associated with preoperative, operative, and postoperative variables in each group. The odds ratio (OR) of the predictive variables and its 95% confidence interval (CI) were calculated.

RESULTS

Out of 144 patients included in this study, 132 were male (92%) and 12 female (8%). The mean age was 71 ± 8 years, ranging from 51 to 90 years old. Table I displays the clinical characteristics and preoperative associated comorbidities of these patients and

Table I. Risk factors and associated pathology

Factor	%	(*n*/total)
Tobacco	74	(98/132)
Diabetes	9	(13/137)
Hypertension	60	(83/138)
Hyperlipidemia	19	(25/128)
Cardiopathy	43	(59/137)
Pulmonary disease	34	(46/137)
Preoperative renal dysfunction	34	(42/125)
Symptomatic cerebrovascular disease	9	(12/134)
Peripheral vascular disease	22	(29/134)

Table II. Postoperative complications

Complication	%	(*n*/total)
Renal failure	48.3	(56/116)
Sepsis	23.2	(27/116)
Cardiac complications	22.7	(27/119)
Pulmonary complications	44.4	(52/117)
Colon ischemia	12.1	(14/116)
Spinal cord ischemia	2.6	(3/116)
Graft thrombosis	3.4	(4/116)

shows the percentage in relation to the number of patients for whom these data were available.

Preoperative creatinine levels ranged from 0.6 mg/dL to 7.0 mg/dL (mean 1.6 ± mg/dL) and hematocrit values from 5 to 49% (mean 31 ± 8%) in 137 patients (data missing for 7 patients).

A systolic blood pressure <80 mmHg was registered in 41% of the cases (59 out of 144 patients) before the operation. Preoperative loss of consciousness was present in 23 patients (16%) and 13 patients (9%) suffered cardiac arrest during the preoperative period.

In 116 patients (81%) the location of the AAA was infrarenal and in 28 cases (19%) suprarenal involvement was noticed. The mortality rates were 45% and 54%, respectively, and the difference was not statistically significant. In 136 patients (94%) it was possible to estimate the aneurysm size by radiological examination during the preoperative period or during the surgical procedure, prior to opening the aneurysm sack. All of the aneurysms but one measured >5 cm in diameter, and in 94 cases (65%) the dimension was >7 cm. With regard to the type of rupture, in 112 cases (78%) a retroperitoneal hematoma was corroborated, 28 patients (19%) suffered free rupture, 3 patients (2%) presented with an aortocava fistulae, and in one case (1%) a rupture into the duodenum occurred.

The left renal vein was ligated in 38 patients out of 137 patients (28%). During the procedure, eight patients (6%) died before aortic cross-clamping could be achieved. An infrarenal aortic cross-clamping was performed in 94 patients (65%) and the remaining 42 (29%) cases required clamp placement at a higher level.

A tube graft was implanted in 53 patients (37%), a bifurcated graft in 73 cases (51%), and grafting was not possible in 18 cases (12%) because the patient died on the operating table before the graft could be completely sewn. Among 126 patients in whom grafting was completed, an associated surgical procedure was performed in 15 (12%) and in 63 cases (50%) a patent inferior mesenteric artery was ligated. In 102 out of 122 patients (84%) with patent hypogastric arteries, at least one of them was preserved.

Complications related to venous iatrogenic injuries leading to excessive bleeding were noted in four patients—all of them died. A cell saver was employed in 42 patients (29%).

In 131 cases (91%) it was possible to glean information related to the magnitude of intraoperative bleeding from the medical charts. To calculate the data the variable was divided into two categories—<2000 cc and ≥2000 cc—and the volume of aspirated blood from the surgical field, added to 500 cc estimated as unaccountable blood loss, was take into account. In 91 patients (69.5%) the blood loss was considered >2000 cc.

Coagulopathy was recognized in 29 out of 121 patients (24%). Table II displays the registered complications during the postoperative period.

The in-hospital mortality rate was 47% (68 out of 144 patients), with 25 of the deaths occurring in the operating room (36%). The causes of death identified were bleeding, 35% (24 patients); multiorgan failure, 34% (23 patients); cardiac complications, 21% (14 patients); respiratory failure, 4% (3 patients); postoperative renal insufficiency, 3% (2 patients); and intestinal ischemia, 3% (2 patients).

The mean age of those who died was only slightly higher than that of survivors, 73 and 69 years old, respectively; however, these differences proved to be statistically significant ($p = 0.01$). The patients older than 75 had a significantly higher mortality rate ($p = 0.04$) than that for patients younger than 65 years: 56% (27/48) and 32% (7/22), respectively. Although the mortality rate was higher among women (58%, 7/12 patients) than among men (46%, 61/132 patients), the difference was not statistically significant.

The mean creatinine level in survivors was 1.4

Table III. Association between qualitative and quantitative variables and mortality

Variable	*p*
Gender	0.42
Age	0.01
Diabetes	0.19
Hypertension	0.75
Cardiopathy	0.79
Pulmonary obstructive disease	0.42
Symptomatic cerebrovasc. disease	0.11
Preoperative creatinine	0.03
Hematocrit	0.02
Peripheral vascular disease	0.09
Hypotension (<80 mmHg)	<0.01
Loss of consciousness	<0.01
Cardiac arrest	0.53
Aneurysm location (infrarenal/suprarenal)	0.44
Iliac involvement	0.40
Aneurysm size (≤7 cm/>7 cm)	0.24
Free rupture	0.04
Left renal vein ligature	<0.01
Aortic cross-clamping (infrarenal/noninfrarenal)	0.23
Type of grafting (bifurcated/tube)	0.45
Ligature of a patent inferior mesenteric artery	0.03
Preservation of hypogastric patency	0.01
Associated surgery	0.26
Venous technical complications	0.01
Cell saver	0.45
Blood loss (<2000 cc/≥2000 cc)	<0.01
Renal failure	<0.01
Sepsis	0.01
Coagulopathy	<0.01
Cardiac complications	<0.01
Pulmonary complications	0.49
Colon ischemia	0.48
Prosthetic graft complications	<0.01
Reoperation	0.08

Table IV. Independent predictors of death

Variables	*p*	OR	95% CI
Preoperative			
Age	<0.01	1.1	1.0-1.2
Hematocrit	0.18	1.0	0.9-1.1
Preoperative creatinine	0.06	1.5	0.9-2.5
Loss of consciousness	0.50	1.5	0.4-5.9
Hypotension <80 mmHg	0.01	3.2	1.2-8.6
Free rupture	0.09	2.9	0.8-10.2
Intraoperative			
Left renal vein ligature	0.07	3.6	0.8-14.8
Patent IMA ligature	0.39	0.6	0.2-1.6
HA patency preserved	0.24	0.4	0.1-1.6
Venous technical complication	0.28	2.4	0.4-13.1
Blood loss ≥2000 cc	<0.01	4.4	1.5-12.4
Postoperative			
Renal failure	<0.01	7.1	2.3-21.2
Cardiac complications	<0.01	6.8	2.0-23.5
Coagulopathy	<0.01	7.1	2.0-24.5
Prosthetic complications	0.60	1.7	0.1-15.0
Sepsis	0.16	2.2	0.7-7.1

HA, hypogastric artery; IMA, inferior mesenteric artery.

mg/dL and for patients who died, 1.8 mg/dL; the difference was statistically significant ($p = 0.03$).

Table III shows the results of univariate analysis for death, and Table IV lists the independent predictors of mortality that were identified in the multivariate logistic regression model: age, preoperative hypotension <80 mmHg, blood loss >2000 cc, postoperative renal failure, coagulopathy, and cardiac complications.

DISCUSSION

The 47% in-hospital mortality rate reported in this study confirms once again that surgical treatment for ruptured AAA continues to be a challenging operation that is associated with an unacceptably high, early mortality risk and whose main causes of death are related to the magnitude of bleeding. There is evidence that, until recently, emergency surgery has been performed more frequently than elective procedures in octogenarians,[3-5] and usually elderly patients operated on for ruptured AAA have higher mortality rates.[2,6,7] Furthermore, advanced age is frequently considered an independent predictor for early death,[8-13] and older age was the strongest predictor for survival in a trial in North Carolina hospitals, in which patients older than 65 had an operative mortality rate >50%.[14] In the present report, age was also identified as an independent predictive factor for mortality; the death rate among patients older than 75 was 56% whereas in patients younger than 65 it was 32%.

However, although other authors have found in some cases higher mortality rates for elderly patients, they have not found advanced age to be a significant predictor for outcome.[15-18] An operative death rate as low as 37% in octogenarians was reported by Harris et al. more than a decade ago,[19] and an even lower figure (23%, 3/11 patients) was mentioned by Crawford in a 1994 editorial paper criticizing the Harborview experience.[13,17]

Several studies[20,21] support the fact that elderly patients, once they have survived the operation, can enjoy a long-term life expectancy similar to that

of the general population in the same age-group. So it seems reasonable to consider that, although advanced-age patients are exposed to increased surgical mortality risks, age per se is not a contraindication for surgical treatment in the case of aneurysm rupture and physiological age looks to be more relevant than chronological age.

In our study it was not possible to identify any preoperative comorbid condition that could be used as a predictor of early death; this finding is in concordance with other reports.[8,15,18] Amazingly, in some patients classical risk factors, such as hypertension or chronic obstructive pulmonary disease, seemed to be related to lower mortality rates.[2,6] However, a variety of comorbidities, such as cardiopathy or bronchopathy, have been pointed out as being important factors determining outcome,[9,22,23] and it seems very unlikely that patients at advanced stages of these diseases could face an operation in the same way as patients without those conditions. With regard to cardiopathy, worse results should be expected for patients with recent electrocardiogram (ECG) alterations or myocardial infarction and those with chronic heart failure, as these conditions contribute to cause of death. It is also possible that the expected impact of comorbid factors on the operative mortality rate could be overwhelmed by the severe consequences of hypovolemic shock in patients with ruptured AAA and that patients with more severe comorbidities died before arriving at the hospital.

There is almost unanimous agreement that preoperative clinical variables reflecting the magnitude of bleeding and hypovolemia, such as hypotension, shock, or loss of consciousness, are associated with a significantly higher mortality rate. In the present report, preoperative hypotension <80 mmHg was found to be an independent predictive factor of death, as in other studies,[8,15,18,22] and the necessity to initiate means of resuscitation was considered. Controversy remains around this issue, however, because even though some studies, mainly in the field of vascular trauma, have pointed out that preoperative resuscitation could improve survival, the length or amount of resuscitation that would be of benefit before surgery has yet to be determined.[15] Patients presenting with loss of consciousness suffer deeper degrees of shock, so worse results should be presumed.[12,15] Patients experiencing preoperative cardiac arrest are also prone to extremely high mortality rates,[13,14,18,22] even though an absolute mortality risk could not be demonstrated.[17] In our report, 17 out of 23 patients with loss of consciousness died (74%), and although it was not a predictor of death, probably because of the small sample size, its association was statistically significant in the univariate analysis.

The type of rupture is an important factor determining outcome; in two studies, those patients presenting with free rupture faced worse survival rates.[11,22] Nonetheless, other investigators did not find it to be an important element.[18] This discrepancy could be explained in part by the fact that around 38 to 64% of all patients with ruptured AAA die outside the hospital; many of them suffer intraperitoneal bleeding and will not arrive at the hospital in time to be saved.[1]

Lower levels of hematocrit or hemoglobin are frequently mentioned as being related to poor outcome because of their evident relation to the magnitude of bleeding; however these levels were not reliable enough to predict death in acute hemorragic shock, and in the present study hematocrit was only associated with death in the univariate analysis—it was not an independent predictor of death. Raised preoperative creatinine levels alone are also not predictive of death. These patients suffer the multiorgan consequences of hypovolemia and bleeding, and we found that intraoperative blood loss of >2000 cc was a unique intraoperative predictor of death, showing more reliably the magnitude of rupture and possible technical complications. Technical venous complications were recognized in only four patients, all of whom died, and were relevant only in the univariate analysis. This negative factor may have been underreported by surgeons, and its adverse effect on survival has been already proved by others.[18]

In our experience, coagulopathy was an independent predictor of mortality. It has already been demonstrated to be a meaningful variable associated with operative death in some reports[17,24] and was the most important factor in Chen et al.'s series.[23] It has a multifactorial etiology and can be easily recognized by quick blood tests, so early measures must be taken for its prevention or correction.

As should be expected and in concordance with the previous discussion, cardiac complications represent a common cause of death after emergency AAA repair. They were found to be an independent predictor for mortality in the present report. Postoperative renal failure was also identified as being an independent predictor of mortality, in agreement with other authors.[8,18,23] Multiorgan failure is another frequent postoperative complication and can be the cause of death 24-48 hr after patients undergo surgery for ruptured AAA, as the present report suggests. A poor outcome can be presumed with an early increase in creatinine and bilirrubine levels.[25] Panneton et al. reported a 100% mortality

rate for patients who developed multiorgan failure and they have raised the ethical question about withholding life-supportive measures in this high-risk group.[18]

Ischemic colitis is another postoperative complication that has been related to mortality occurring 48 hr after surgery;[8,14,23] however, this finding was not confirmed in our study. In a recent report by Maziak et al., sepsis seemed to contribute little to postoperative death;[25] others, however, found it to be a predictor of death.[8] In the present report, sepsis was only associated with death in the univariate analysis.

From the data and reports presented above, we can conclude the following:

1. Advanced age seems to be an important factor related to worse outcome for patients undergoing surgery for ruptured AAA. However, despite the fact that several studies, including ours, were able to identify some preoperative variables as predictors of mortality, an absolute mortality risk has not yet been confirmed and the controversy about the predictability of this factor remains. Surgery, as the only possibility for survival, cannot be denied on this basis alone, and a patient-by-patient decision must be made, with consideration of the particular characteristics of each patient.
2. Patients operated on for symptomatic but intact aneurysms have lower mortality rates than those who undergo surgery when there is rupture. Most patients present symptoms before rupture, so at present a better expected survival could be offered with early diagnosis and treatment.[17,26,27]
3. Selective screening in population groups determined to be at risk should be considered, taking into account that (a) results for elective repair, in contrast to those for surgery for ruptured AAA, have steadily improved to around 5% mortality rate; (b) long-term life expectancy for those patients who survive operative treatment for rupture is almost equal to that for the same age-group in the general population;[20] and (c) economic savings achieved by performing elective repair of AAA, and thus limiting emergency surgical treatment for AAA rupture, are significant.[28]

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