

# Open surgery in endovascular aneurysm repair era: simplified classification in two risk groups owing to factors affecting mortality in 137 ruptured abdominal aortic aneurysms (RAAAs)

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**Abstract** Our objective is to identify in 137 true RAAAs operated consecutively in open surgery: (1) diagnostic therapeutic aspects capable of influencing results, (2) risk classes with different prognosis, (3) any situations where the prognosis is so negative that surgery is not recommended. The relationship of 16 anamnestic, clinical and technical parameters prospectively collected with 30-day mortality was retrospectively evaluated by uni- and multivariate analyses. Thirty-day mortality was 37%. The univariate analysis identified as mortality predictors  $Hb \leq 8$  g/dl and circulatory shock at hospitalisation, but following the multivariate analysis only circulatory shock was a certainly significant risk-factor. The cumulative effect on mortality of the two parameters identified at univariate analysis translates into a statistically significant

difference in mortality between two groups of patients: A (no or just one risk-factor) and B (two risk-factors). To reinstate euvoemia, rather than adequate haemoglobin values, improves the chances of success. A simple prognostic index into two risk classes is feasible, but abstention from surgery is not justified in any type of patient.

**Keywords** Aortic aneurysm · Abdominal · Ruptured · Open surgery · Prognosis

## Introduction

The most recent reviews of the literature [1, 2] show that the high mortality that still characterises ruptured abdominal aortic aneurysms (RAAAs) today can be the result of numerous types of variables, including logistic ones (such as the frequent transfers of the patient from the place where he was first hospitalised to reference Centres), to anamnestic and clinical variables of the patient themselves and, finally, to those relating to diagnostic-therapeutic technique and timing. With reference to the variables mentioned above, we have compared the mortality found in 137 RAAAs treated consecutively in open surgery with numerous related factors, to identify: (1) risk classes with different prognosis, (2) aspects relating to the diagnostic-therapeutic management of the patient influencing results; (3) any situations where the prognosis is so serious that surgery is not recommended.

## Materials and methods

Data from 137 consecutive patients undergoing open surgery repair with a confirmed diagnosis of ruptured

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abdominal aortic aneurysm (RAAA) were prospectively collected and retrospectively evaluated. Rupture was defined as extravasation of blood outside the aortic wall (extra-aortic haematoma) confirmed by computed tomography (CT) and/or during laparotomy. Four patients died at the time they were admitted to Emergency & Admittance Unit (E&A) and another 39 patients, operated urgently due to fissuring and/or acute symptomatology, but without true rupture, were not considered.

The relationship of 16 parameters (Table 1) with 30-day mortality was analysed by both univariate and multivariate analyses performed, respectively, through a Chi-square test and Logistic Regression model according to SPSS statistical software (version 13; SPSS, Chicago, IL, USA). Finally, the cumulative effect of the risk factors found to be significant in the univariate analysis was considered, dividing the patients into three classes according to the number (ranging from 0 to 2) of risk-factors present at the same (Table 2). The last statistical comparison among mortalities of the three classes then allow further simplification into just two groups of patients: A (no or just one risk-factor) and B (two risk-factors).

#### Study group

Of the 137 patients, 119 were men (87%) with an average age of 72 (range 45–95, IQR 66–77) and 18 women (13%) with an average age of 80 (range 71–95, IQR 76–82); 58 patients were  $\geq 75$  years old, and among these, 36 were over eighty (Table 3).

In 63 cases (46%), the patient arrived under our observation after initial hospitalisation in another Hospital. On

**Table 2** Classes relative to the number of risk factors for mortality identified at univariate analysis and present at the same time in each patient

No. of risk-factors	No. of patients (%)	Mortality (%)
0	33 (24)	5 (15)
1	63 (46)	21 (33)
2	35 (26)	22 (63)

entering our hospital, 83 patients (61%) had localised pain in the abdomen, back or both and 74 patients (54%) had circulatory shock (defined as systolic blood pressure  $\leq 80$  mmHg).

Following a haemochemical test carried out immediately after admission to hospital, haemoglobin values (Hb)  $\leq 8$  g/dl were found in 12 patients (8.7%).

From the anamnestic and laboratory data, the various comorbidities indicated in Table 4 emerged.

69 patients (50%) were operated within 6 h of the start of symptomatology, while the remaining 68 were operated after 6 h. While 23 patients (17%) underwent surgical treatment on the basis of the clinical assessment, supported by a scan carried out in E&A, an Angio-CT was performed on 86 patients. In these cases, it was possible to measure the maximum diameter of the lesion, with an average of  $7.38 \pm 1.94$  cm (range 3.10–13.56 cm): in particular, in 16/86 patients (18.8%) the maximum diameter was  $\leq 5.5$  cm.

The extension of the aneurysm was suprarenal in 9 patients (6%), juxtarenal in 16 (12%) and infrarenal in 112 (82%). In the 112 infrarenal cases, clamping was performed above the renal arteries in 19 patients (17%),

**Table 1** Statistical analysis of 16 parameters considered correlated to 30-day mortality

Parameter	Univaried analysis ( <i>p</i> )	Multivaried analysis ( <i>p</i> )	Odds ratio
Age	ns	–	2.1
Sex	ns	–	1.2
COPD	ns	–	0.9
CAD	ns	–	1.2
CRF	ns	–	2.0
Hypertension	ns	–	0.8
PAOD	ns	–	1.1
Diabetes	ns	–	1.0
Pain	ns	–	0.5
Hb $\leq 8$ g/dl in E&A	$<0.025$	ns	5.2
Circulatory shock	$<0.005$	$<0.005$	3.0
Timing	ns	–	1.8
Diameter AAA	ns	–	1.6
Location AAA	ns	–	1.7
Clamping location	ns	–	1.5
Replacement type	ns	–	1.7

**Table 3** Age and gender of 137 patients correlated to 30-day mortality

Age (years)	No. of patients (%)	Males	Females	Mortality (%)	Mortality, M vs. F (%)	<i>p</i>
<60	10 (7.3)	10	0	2 (20)	20 vs. 0	–
60–75	68 (49.6)	66	2	22 (32.4)	32 vs. 50	ns
75–80	23 (16.8)	18	5	10 (43.5)	44 vs. 40	ns
≥80	36 (26)	25	11	17 (47.2)	56 vs. 27	ns
Total	137	119	18	51 (37.2)	38 vs. 33	ns

**Table 4** Mortality and preoperative comorbidities

Pre-operative comorbidity	No. of patients (%)	Mortality (%)
COPD	46 (33.6)	16 (34.8)
CAD	56 (40.9)	22 (39.2)
CRF	44 (32.1)	21 (47.7)
Hypertension	67 (48.9)	23 (34.3)
PAOD	25 (18.2)	10 (40)
Diabetes	16 (11.7)	6 (37.5)

*COPD* preoperative chronic obstructive pulmonary disease [37], *CAD* preoperative coronary artery disease [38], *CRF* chronic renal failure (serum creatinine >1.8 mg/dl) (anamnestic data), *PAOD* peripheral arterial occlusive disease for pre-operative Winsor index <0.80 (anamnestic data)

infrarenal in the remaining 83%. In 62 cases, an aorto-bi-iliac replacement was carried out (45%), in 60 an aorto-aortic replacement (44%), in 7 an aorto-bifemoral replacement (5%) and in 5 an aorto-iliac and a femoral contralateral replacement (4%); finally, in 3 cases (2 due to rupture of the duodenum and 1 for extreme fragility of the aortic wall) an axillo-bifemoral by-pass was performed (2%). The corresponding blood transfusion was performed with an average number of five units of concentrated erythrocytes (range 0–13) per patient, as well as the inter-operation auto-blood transfusion.

## Results

Thirty-day mortality was 51/137 RAAAs (37%): 1 of the 51 (2%) died during induction, 5 (10%) during surgery, 15 (29%) during the first day after surgery, 3 (6%) during the first week and 27 within 30 days (53%). Postoperative complications, causes of death were: first day, rupture of the thoracic aorta, on the second day, 28 multi-organ failures (MOF) and 22 major adverse cardiovascular events. No patient died from graft-related reasons, but one patient who underwent aorto-aortic replacement died as a result of acute myocardial infarction on the fifth day after he underwent a femoro-femoral by-pass cross-over, followed by reinstatement of a normal distal perfusion, made owing

to the thrombosis of the left iliac axis during the first day after surgery for RAAAs.

With regard to mortality, the Hb level and circulatory shock at hospitalisation was statistically significant in the univariate analysis among the 16 parameters. Similarly, circulatory shock at hospitalisation was a significant prognostic factor, for a mortality of 49% in 74 patients with SAP ≤80 mmHg, compared with a mortality of 23% observed in 63 patients with SAP >80 mmHg ( $p < 0.005$ ).

Therefore, in total, the univariate analysis identified as mortality predictors Hb ≤ 8 g/dl and circulatory shock at hospitalisation, but following the multivariate analysis only circulatory shock was a certainly significant risk-factor. The cumulative effect on mortality of the two parameters identified at univariate analysis translates into a statistically significant difference in mortality between group A (26/96 patients without or with only one risk-factor, 27%) and group B (25/41 patients with two risk-factors, 61%) ( $p < 0.001$ ).

## Discussion

While for endovascular aneurysm repair (EVAR) in the case of RAAAs assessments regarding not only the results but also the same possibility of extensive implementation [3–8], are still underway, the experience in open surgery is very extensive, and even over-consolidated results are also subjected to a very high-operative mortality (Table 5 [2, 9–30]).

In the last 20 years, there has been a drop in mortality of about 3.5% for every decade; this apparently modest result, probably due in particular to the routine use of inter-operative recovery auto-haemotransfusion and to the improvement in the measures adopted to prevent and treat MOF [24], could be reassessed considering the greater number of patients, who, compared with the past, manage to reach the hospital and the operating theatre alive, often very elderly and with many co-morbidities. However, what was recently calculated by Bown et al. [25], still remains true: during the 60s operative mortality from RAAAs was 55%, in the 80s, 48%, but it is still currently over 40% (Table 5). As highlighted in the extensive review of literature published in January 2008 by Tambyraja [1], we must continue analysing significant prognostic factors for such

**Table 5** Review of the literature since 2000: mortality of RAAAs in open surgery

Author	Year	Patients	Mortality (%)
Heller [9]	2000	6,775 <sup>a</sup>	30,962 (46)
Merlo [10]	2001	123	55 (45)
Years [11]	2001	413	153 (37)
Alonso-Perez [12]	2001	144 <sup>a</sup>	(47)
Dimick [13]	2002	813 <sup>a</sup>	382 (47%)
Gutierrez-Morlote [14]	2002	99	48 (49)
Hans [15]	2003	101	48 (48)
Piper [16]	2003	147	51 (35)
Markovic [17]	2004	229	123 (54)
Calderwood [18]	2004	137	77 (56)
Dueck [19]	2004	2,280 <sup>a</sup>	921 (40)
Korhonen [20]	2004	836 <sup>a</sup>	395 (47)
Davidovic [21]	2005	406	196 (48)
Acosta [22]	2006	141	104 (74)
Laukontaus [23]	2007	319	121 (38)
Cho [2]	2008	170	65 (38)
Our experience	2008	137	51 (37)

<sup>a</sup> Multicentre registers

mortality, above all in order to assess if it is possible to improve the prognosis influencing the same, through the prompt, intensive adoption of adequate measures of a logistical type and by planning and implementing diagnostic-therapeutic strategies.

### Non-modifiable risk-factors

The figures found in the literature regarding the non-modifiable risk-factors, as advanced age and gender, are conflicting ([4, 7, 12, 20, 28, 32]). Our patients had an average age of 73, and 42% were  $\geq 75$  years old (Table 3). This limit did not appear to be significant for the increase in mortality at the univariate analysis (47 vs. 30% in younger patients), even though the Odds Ratio shows a 2.1 times higher risk in older patients. In our experience, we find a 53% survival rate both in patients of 75 years of age and over considered globally and in only patients over eighty (also the only two operated patients older than 80 years survived). The figure of higher mortality in the female sex reported by several authors [28] is not confirmed by our experience (Table 1). It is interesting to note that the number of female patients out of the total number of RAAAs increases steadily with the increase in age, but we did not find that the female sex is a negative prognostic factor: mortality among women patients (33%) is even apparently lower than that of men (38%), a difference which, in any case, even stratifying patients according to increasing age, never reaches statistical significance.

Again, among factors that cannot be modified (anamnesic pathologies), all co-morbidities analysed (Table 4) do not appear to be crucial in relation to operator mortality. The previous chronic renal failure (CRF) that various authors indicate as significant [11] does not reach significant levels in our opinion, therefore giving the Odds Ratio calculated for this parameter as 2: 48% mortality in patients with CRF versus 32% in patients with a normal renal function (ns).

### Modifiable risk-factors

Going on to consider factors that may suggest a clinical-diagnostic-therapeutic approach able to positively modify the prognosis, we must point out that we analysed in detail the progress of the patient only from the time he reached our hospital, since we did not have sufficient data to assess, in particular, the influence of the fact that 46% of our patients had initially been hospitalised in other Hospitals, and whether the transfer had been a positive or negative factor.

Anemisation with Hb values  $\leq 8$  g/dl on arrival at E&A is a significant parameter for mortality at univariate analysis ( $p < 0.025$ , OR 5.2). A second factor, i.e., circulatory shock, is the only factor to also confirm itself as significant at multivariate analysis ( $p < 0.005$ , OR 3.0), as if achieving the correct pre-operative reinstatement of volemia as soon as possible can offer even better chances of success for the surgical operation than the achievement of optimal Hb values.

Other factors such as the morphological characteristics of RAAAs (pararenal rather than infrarenal extension) and technical, operator details [2, 11, 12, 19], (type of aortic clamping, performed by us on the hiatus only in 17% of infrarenal aneurysms [in every case  $< 10^\circ$ ], with the advantage of avoiding a further ischemic insult to the splanchnic area) were not significant for the patient's survival, confirming that a specific consolidated experience is not a secondary parameter for the result of the operation [2, 9, 13, 23, 33]. Finally, only in specific reference centres, a correct assessment may be made to see if the technical option currently composed of the EVAR may be implemented, and above all if it can cause an improvement in results, even for RAAAs, as various indications recently published seem to suggest [3–7].

### Prognostic factors

For the purpose of identifying prognostic indexes that also include the various risk-factors for RAAAs, various score systems have been used such as the POSSUM, the

APACHE II, the Glasgow Aneurysm Score and the Hardman index, designed and validated for other acute surgical syndromes, but with results that are not univocal, and in any case difficult to use except for analysis of a retrospective type [29, 31, 34, 35]. In order to dispose of a prognostic index that is simple and rapid to calculate, already prior to operating, but obviously also to assess on the basis of objective data the long-term variations in the efficiency and efficacy of our work, also in relation to any adjustments in the diagnostic-therapeutic approach, modifying that already attempted by other authors [1, 31, 36], we decided to divide the patients under observation for RAAAs into two risk groups only that are easy to identify and which, on the basis of the data reported herein, appear to be completely different on the prognostic level: the first with a better prognosis includes patients who have no factor or only one of the significant risk factors (27% mortality in our experience); the second, with a worse prognosis, includes patients with at least two risk-factors (63% mortality,  $p < 0.001$ ). The considered risk factors are those that emerged from our experience: it is possible that different centres from ours identify other, different ones, given that every factor can have an absolute value, i.e., be the expression of aspects of variable significance or specific deficiencies.

Finally, these results allow confirmation that, since also in the group with the worse prognosis the survival rate is not insignificant (equal to 39%), in these cases, it cannot be considered correct to abstain from a surgical treatment which not only saves the patient from certain death but also returns him to a life which in terms of quality and length is almost comparable to that of the general population.

**Conflict of interest** The authors declare that they have no conflict of interest.

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