ORIGINAL ARTICLE **VASCULAR SURGERY**

WHICH ANEURYSM CHARACTERISTICS PREDICT EVAR NON-SUCCESS?

Pedro Pinto Sousa[1], Pedro Brandão[1], Alexandra Canedo[1]

[1]Centro Hospitalar Vila Nova de Gaia/Espinho

*Contacto Autor: pedro_psousa@hotmail.com

Abstract

Introduction: Hostile anatomic characteristics in patients undergoing endovascular abdominal aortic aneurysm repair (EVAR) may lead to technical non-success, late complications, reintervention or death.

Objective: To analyze specific anatomical features of abdominal aortic aneurysms and to study the association with postoperative endoleak and survival.

Methods: Retrospective review of all consecutive elective EVARs between 2010 and 2016, with available data, at one institution, for infra-renal aortic aneurysms. Patients comorbidities and preoperative computed tomography scans were analyzed considering characteristics of the proximal and distal landing zones, the aortic aneurysm and eventual concomitant iliac aneurysm or peripheral occlusive disease. Outcomes were endoleak development and survival.

Results: We analyzed 56 patients, 54 (96%) male with a mean age of 78 (min 61, max 89) years. During a mean of 3.4 years of follow up, 12 (21%) patients developed endoleak (10 type II and 2 type I) and 18 (32%) died. The adjusted analysis showed a significant association between aneurysm angulation (p=0.044), patency of the inferior mesenteric artery and the lumbar arteries (p=0.044) and aneurysm diameter (p=0.009) with endoleak development. All except one endoleak were diagnosed within the first year after EVAR. None of the deaths that occurred during the follow up period were correlated to post intervention aneurysm enlargement or rupture.

Conclusion: Unfavorable aneurysm morphologic characteristics for EVAR may predict complicated endograft placement or higher incidence of post intervention endoleak, which should be taken into consideration. For such clinical cases, complementary endovascular procedures or a surgical approach should be considered.

INTRODUCTION

Endovascular aneurysm repair (EVAR) has become the standard method for abdominal aortic aneurysm (AAA) treatment. The main reason for that evolution is the minimally invasive approach when compared to open surgery with consequent lower short-term patient morbidity and mortality.[1,2]

Nevertheless, each manufacture establishes their own instructions for use for specific aortic stent grafts which requires precise anatomic characteristics (aortic neck diameter, length and neck angle; iliac artery morphology) so that the patient may be suitable for EVAR. Still, the literature describes that about 20% of patients have hostile necks for current endografts[3] while some other studies consider that 60% of AAA patients are excluded from EVAR due to their unfavourable anatomy.[4]

Considering that data, recent endograft evolution has expanded its applicability from conventional AAA with favourable anatomy to aorto-iliac aneurysms with more complex anatomy, particularly in high-risk patients.

Notwithstanding initial technical deployment success, endograft failure may develop along follow up secondary to stent graft migration, endoleak or sac enlargement which may lead to a higher risk of aortic rupture. And the reason for that non-success in not necessarily correlated to technical skills but to specific anatomic predictors. That is why, despite latest advancements, EVAR on patients with unfavourable anatomy remains a challenge.

OBJECTIVE

The purpose of the present study was to analyze the data from previous EVAR's conducted in our Vascular Surgery department considering anatomic characteristics and correlate them with technical short and long-term success (endoleak development and survival).

MATERIALS AND METHODS

We conducted a retrospective study. Data from every patient who underwent elective EVAR for an infra-renal

AAA between January 2010 and December 2016 at our Vascular Surgery department was retrospectively reviewed. The study excluded patients who underwent EVAR for ruptured, thoracoabdominal, pararenal or isolated iliac aneurysms.

Patient demographic information was obtained from the electronic medical record, available at the Institutional software program, SClinico®, including age, sex and medical history with analysis of risk factors (smoking, chronic obstructive pulmonary disease (COPD), chronic renal disease, dyslipidemia, diabetes mellitus and hypertension) and described in table 1. Data was analyzed in conformity with applicable safety standards published by the *Serviços Partilhados do Ministério da Saúde*.[5]

Table 1 **Pre-operative patients characteristics**

	N
Age, mean (SD)	78 (5)
Male, n (%)	54 (96%)
Smoking, n (%)	42 (78%)
COPD, n (%)	16 (30%)
Chronic Renal Disease, n (%)	18 (33%)
Dyslipidaemia, n (%)	36 (67%)
Diabetes Mellitus, n (%)	12 (%)
Hypertension, n (%)	44 (83%)

SD: Standard deviation

All measurements and evaluations were based on the computed tomographic angiography (CTA) previous to the procedure. The software used for this propose was Osirix with implementation of center lumen line. Measurements were always made by the same operator to avoid inter-observer variability and done three times for each parameter analyzed and used the mean of those values. Aneurysm characteristics taken into consideration were:

1) The proximal landing zone: cross sectional diameter (inner to inner), length from the inferior renal artery to the aneurysm, presence of thrombus (< 25% of cross sectional lumen, 25-50% or >50%) and calcification (<25% of the perimeter of the aortic circumference, 25-50% or >50%);
2) The distal landing zone: length of the endograft limb anchored on a disease-free zone and cross sectional diameter of that zone;
3) Eventual presence of concomitant iliac aneurysm. Only accepted fusiform aorto-iliac aneurysms, without involvement of the internal or external iliac artery. No maximum aneurysm diameter was established;
4) Eventual presence of concomitant peripheral occlusive disease identified on the pre-operative CTA or Doppler ultrasound or by a reduced ankle-brachial pressure index;
5) Aneurysm: maximum cross sectional diameter (inner to inner), axis deviation (ratio between central lumen-line distances/straight-line distances), mural thrombus (< 25% of cross sectional lumen, 25-50% or >50%) and patency of the inferior mesenteric artery and the lumbar arteries with registration whenever their diameter was superior to 3mm. According to the aneurysm diameter, patients were divided into three groups (> 60mm; 60 – 70mm and > 70mm).

Statistical analysis was performed using the IBM SPSS Statistics®. Descriptive analysis was performed using mean and standard deviation or minimum/maximum for continuous variables, and absolute and relative frequencies for categorical variables. An exploratory univariate analysis was preformed to assess possible factors associated to outcomes; the T-test was used for continuous variables and the X^2 for categorical variables. Then, a multivariate analysis (logistic regression) was performed to evaluate which risk factors were associated with late complications. Primary outcomes (used as dependent variables for multivariate analysis) were endoleak development or death during follow-up (FU). Also, subgroup analysis for differences between endoleak type (I and II) was performed. Statistical significance was set for a p-value < 0.05 in inferential analysis and described in table 2.

The patients included in this study underwent a surveillance protocol following the European Society of Vascular Surgery guidelines[6] applicable at the intervention date. Every patient submitted to AAA repair by EVAR received: best medical treatment including aspirin, statin and β-blocker if tolerated; plain radiographs with anteroposterior and lateral projections and CTA with delayed images at one month and twelve after the procedure. If no endoleak and a good component overlap, thereafter annually, otherwise would be orientated accordingly to the findings. Complementary, they received a medical consultant with evaluation of peripheral pulses. Once missed an appointment the patient would be re-scheduled. Endoleaks present at the end of the procedure on the control angiogram were excluded. Only new endoleaks during follow up were considered.

RESULTS

The studied population comprised 56 patients, 54 (96%) males with a mean age of 78 (minimum 61, maximum 89) years.

Throughout a mean of 3.4 years of FU, 12 (21%) patients developed endoleak. We detected 2 Type Ia endoleaks due to a caudal migration of the stent graft and 10 type II endoleaks due to back-bleeding (from the inferior mesenteric artery in four cases and in the other six from lumbar arteries). All except one endoleak were diagnosed within the first year after EVAR procedure. During FU, 18 (32%) patients died. None of the deaths occurred, were correlated to post intervention aneurysm enlargement or rupture. Four patients died due to a malignant disease, 8

Table 2 **Predictors of endoleak and mortality in multivariate analysis not considering the aneurysm characteristics**

	Endoleak	P	Mortality	P
Total, n (%)	12 (21%)	n.a.	18 (32%)	n.a.
Female	2 (17%)	0.060	2 (11%)	0.014*
Male	10 (83%)		16 (89%)	
Concomitant iliac aneurysm				
Yes	3 (25%)	0.080	7 (39%)	0.090
No	9 (75%)		11 (61%)	
Peripheral occlusive disease				
Yes	2 (17%)	0.060	8 (44%)	0.080
No	10 (83%)		10 (64%)	

n.a.: not applicable. * statistical significant

due to a cardiovascular event (coronary or cerebrovascular) and the other of unknow cause.

The adjusted multivariate analysis of preoperative clinical information showed only a statistically significant association between gender (female) and death during follow-up (p=0.014). COPD showed a positive trend with endoleak development.

When considering the proximal landing zone only aneurysm angulation superior to 60º had a statistical correlation with endoleak development (p=0.044) and none analyzed factor correlated statistically to death during FU.

Reflecting aneurysm diameter analysis, the diameter larger to 70mm was predictive of endoleak development (p=0.009). According to the ROC curve, a diameter of 64mm was the threshold. Patency of the inferior mesenteric artery (IMA) and the lumbar arteries (p=0.044) were associated to endoleak. Despite without statistical significance we noticed a tendency for endoleak when in presence of a significant axis deviation.

None of the factors analyzed concerning the distal landing zone were predictors of endoleak nor death during FU.

DISCUSSION

We present a retrospective study with a reduced pool of patients that led to limited data, and still a short period of follow-up where the specificities of each endograft were not analysed. All those factors imply cautionary measurers when looking at the results. The authors tried to compare the results with what is written in the literature. Recently, on the basis of different experience, there has been a trend in the literature towards preventing endoleaks instead of treating their complications once they develop. For such specific clinical cases with unfavorable anatomic characteristic, additional previous or intra-operative procedures should be considered while undertaking EVAR. Analysing our data and, despite the fact that most of our endoleaks were diagnosed within the first year after intervention, which suits the literature, and even considering the fact that still, most of the time they are not associated with patient's mortality, they may imply further complementary procedures and increased morbidity, thus should be prevented.

Type II endoleaks were the most frequent type of endoleaks and are associated with patency of aortic side branch vessels, specially the inferior mesenteric artery. These results are in concordance with other published studies. Piazza M *et al*, suggested that more aggressive intraoperative aneurism sac embolization should be considered for patients with a preoperative aneurysm sac volume >125 cm^3.[7] He published an article where he suggested that thrombus volume <35% was an additional predictor for endoleak type II and endoleak-related reintervention among patients at risk.[8] Muthu *et al* have already described routine intraoperative selective IMA embolization and thrombin injection into the aneurysm sac just before EVAR.[9]

Type I endoleaks occurred in patients with severe aneurysm angulation and larger aneurysms were associated with both types of endoleaks. Schuurmann *et al* identified maximum curvature over the length of the aneurysm sac (>47 m-1; p=0.023), largest aneurysm sac diameter (>56 mm; p=0.028), and mural neck thrombus (>11° circumference; p<0.001) as independent predictors of late migration and type Ia endoleak. Endograft failure may be associated with this factors because they do not provide a stable attachment of the endograft and leave it more prone to change over time.[10] Large aneurysm diameter and high curvature over the proximal part of the sac may reduce positional stability, inducing movement of the endograft within the sac.

Association between COPD and endoleak is debatable. Literature suggests an association between lung tissue destruction that occurs in emphysema and aortic wall degeneration.[11]

Analysing our data, we noticed that women have not benefited as men from EVAR, presenting higher mortality. Bendermacher BL *et al* published the same results suggesting that differences in hormones, a higher rate of undiagnosed cardiovascular disease and also anatomical differences between them could influence the outcome.[12]

Table 3 Predictors of endoleak and mortality in multivariate analysis considering aneurysm characteristics

	Endoleak	P	Mortality	P
Axis deviation				
Yes	8 (67%)	0.080	4 (22%)	0.062
No	4 (33%)		14 (78%)	
Patency of IMA or lumbar				
Yes	11 (92%)	0.044*	7 (39%)	0.090
No	1 (8%)		11 (61%)	
Thrombus				
< 25%	6 (50%)	0.060	6 (33%)	0.070
25-50%	5 (42%)		4 (22%)	
>50%	2 (8%)		8 (44%)	
Cross sectional diameter				
< 60mm	3 (25%)	0.009*	11 (61%)	0.055
60-70mm	2 (17%)		4 (22%)	
>70mm	7 (58%)		3 (17%)	
Proximal landing zone Thrombus				
< 25%	3 (25%)	0.090	10 (56%)	0.060
25-50%	5 (42%)		4 (22%)	
>50%	4 (33%)		4 (22%)	
Neck angulation				
< 60%	1 (8%)	0.044*	14 (78%)	0.100
>60%	11 (92%)		4 (22%)	
Neck length				
< 15mm	6 (50%)	0.100	8 (44%)	0.080
> 15mm	6 (50%)		10 (56%)	
Calcification				
< 25%	4 (33%)	0.060	3 (17%)	0.070
25-50%	7 (58%)		10 (56%)	
>50%	1 (8%)		5 (28%)	
Distal landing zone				
Length < 20mm	2 (17%)		8 (44%)	0.080
Length > 20mm	10 (83%)	0.060	10 (56%)	

n.a.: not applicable. * statistical significant

REFERENCES

1. Blankensteijn JD, de Jong SM, Prinssen MM, et al; Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. N Engl J Med. 2005; 352(23):2398-2405
2. Lederle FA, Freischlag JA, Kyriakides TC, et al. Outcomes following endovascular vs open repair of abdominal aortic aneurysm. JAMA. 2009;302(14):1535-1542.
3. Malina M, Resch T, Sonesson B.EVARand complex anatomy: An update on fenestrated and branched stent grafts. Scand J Surg 2008;97:195-204
4. Prinssen M, Verhoeven EL, Buth J, et al: A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004; 351:1607-1618
5. http://ciberseguranca.spms.min-saude.pt/wp-content/uploads/2018/03/Guia-Privacidade-SMPS_RGPD_digital_20.03.172-v.2.pdf
6. Eur J Vasc Endovasc Surg (2011) 41, S1eS58
7. Piazza M et all; Role of aneurysm sac embolization during endovascular aneurysm repair in the prevention of type II endoleak-related complications;J Vasc Surg 2013 Apr;57(4):934-41. doi: 10.1016/j.jvs.2012.10.078. Epub 2013 Feb 4.
8. Piazza M et all, Definition of Type II Endoleak Risk Based on Preoperative Anatomical Characteristics, J Endovasc Ther. 2017 Aug;24(4):566-572. doi: 10.1177/1526602817712511. Epub 2017 Jun 5
9. Muthu C, Maani J, Plank LD, Holden A, Hill A. Strategies to reduce the rate of type II endoleaks: routine intraoperative embolization of the inferior mesenteric artery and thrombin injection into the aneurysm sac. J Endovasc Ther 2007;14:661-8
10. Schuurmann RCL et al, Aortic Curvature Is a Predictor of Late Type Ia Endoleak and Migration After Endovascular Aneurysm Repair, J Endovasc Ther. 2017 Jun;24(3):411-417. doi: 10.1177/1526602817700378. Epub 2017 Mar 28.
11. T. Ohrlander et al; Preoperative Spirometry Results as a Determinant for Long-term Mortality after EVAR for AAA; European Journal of Vascular and Endovascular Surgery 43 (2012) 43e47
12. Bendermacher BL et al; Influence of gender on EVAR outcomes with new low-profile devices; J Cardiovasc Surg (Torino). 2013 Oct;54(5):589-93.
13. Gallitto E et all, Impact of iliac artery anatomy on the outcome of fenestrated and branched endovascular aortic repair; J Vasc Surg. 2017 Sep 6. pii: S0741-5214(17)31359-9. doi: 10.1016/j.jvs.2017.04.063. [Epub ahead of print]