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Programa de Pós-graduação em Ciências Aplicadas à Cirurgia e à Oftalmologia

Joice Cristina Daltoé Inglez

A INFLUÊNCIA DE FATORES CLÍNICOS E MORFOLÓGICOS NA MORTALIDADE GERAL E RELACIONADA AO GÊNERO APÓS O TRATAMENTO ENDOVASCULAR DO ANEURISMA DE AORTA ABDOMINAL

Belo Horizonte

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A INFLUÊNCIA DE FATORES DE RISCO CLÍNICOS E MORFOLÓGICOS NA MORTALIDADE APÓS O TRATAMENTO ENDOVASCULAR DO ANEURISMA DE AORTA ABDOMINAL.

JOICE CRISTINA DALTOÉ INGLEZ

Tese de Doutorado defendida e aprovada, no dia primeiro de setembro de dois mil e vinte e dois, pela Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Ciências Aplicadas à Cirurgia e à Oftalmologia da Universidade Federal de Minas Gerais constituída pelos seguintes professores:

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Belo Horizonte, 1º de setembro de 2022.

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Dedico este doutorado à minha mãe, Iracema, que insistiu (com veemência) para que fosse concluído.

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"Every day you may make progress. Every step may be fruitful. Yet, there will stretch out before you an ever-lengthening, ever-ascending, ever-improving path. You know you will never get to the end of the journey. But this, so far from discouraging, only adds to the joy and glory of the climb."

(Sir Winston Churchill)

RESUMO

Objetivos: Avaliar a relação entre variáveis clínicas e morfológicas dos pacientes submetidos ao tratamento endovascular de aneurisma de aorta abdominal com a mortalidade geral e por gênero, endoleaks e reintervenções relacionadas ao aneurisma nos primeiros 30 dias após a cirurgia e no acompanhamento subsequente.
Métodos: Estudo de coorte com 345 pacientes submetidos ao tratamento endovascular de aneurisma de aorta abdominal entre 2013 e 2020.
Resultados: Nos primeiros 30 dias após a cirurgia, um maior grau calcificação do colo proximal foi correlacionado ao aumento da mortalidade (OR = 1.04, 95% CI 1.005–1.07, p = 0.024). O maior diâmetro do colo proximal contribuiu para aumento do risco de endoleak tipo 1A (OR = 1.18, 95% CI 1.02–1.38, p = 0.026). O maior diâmetro da artéria ilíaca comum esquerda (OR = 1.07, 95% CI 1.01–1.12, p = 0.012) contribuiu para o aumento de reintervenções relacionadas ao aneurisma. No período de acompanhamento, em uma média de 2,8 anos, idade avançada (OR = 1.04, 95% CI 1.01–1.08, p = 0.009), eventos cerebrovasculares prévios (OR = 2.62, 95% CI 1.19–5.73, p = 0.016), doença pulmonar obstrutiva crônica (OR = 2.19, 95% CI 1.02–4.70, p = 0.043), ex-etilismo (OR = 1.52, 95% CI 1.02–2.27, p = 0.039) e uma maior angulação do colo proximal (OR = 1.01, 95% CI 1.003–1.03, p = 0.014), foram fatores que contribuíram para o aumento da mortalidade geral. O maior diâmetro da artéria ilíaca comum direita foi associado a um maior risco de endoleaks tipo 1B (OR = 1.05, 95% CI 1.01–1.09, p = 0.028). O maior calibre da artéria ilíaca comum esquerda (OR = 1.05, 95% CI 1.009–1.10, p = 0.019) foram fatores de risco para reintervenções relacionadas ao aneurisma. Na análise de sobrevida (*survival analysis*), os fatores de risco que contribuíram para o aumento da mortalidade foram idade avançada, ex-etilismo e fibrilação atrial. Os fatores de risco relacionados ao aumento de mortalidade no gênero masculino foram ex-etilismo (HR = 1.43, 95% CI 1.02–2.01, p = 0.036) e o maior diâmetro da artéria ilíaca comum esquerda (HR = 1.03, 95% CI 1.005–1.06, p = 0.022). No gênero feminino, os fatores de risco para mortalidade foram tabagismo (HR = 6.27, 95% CI 1.85–21.23, p = 0.003), infarto agudo do miocárdio (HR = 9.99, 95%CI 1.44–69.32, p = 0.020), doença pulmonar obstrutiva crônica (HR = 9.00, 95% CI 2.11–38.37, p = 0.003) e ex-etilismo (HR = 4.29, 95% CI 1.39–13.23, p = 0.011).
Conclusão: Nos pacientes submetidos a EVAR, idade avançada, eventos cerebrovasculares prévios, ex-etilismo, doença pulmonar obstrutiva crônica e

fibrilação atrial foram associados a maior mortalidade a médio prazo. O maior diâmetro dos colos proximal e distal foi relacionado a endoleaks e reintervenções. Características morfológicas do aneurisma, que não o diâmetro, foram fatores prognósticos para mortalidade.
Palavras-chave: aneurisma de aorta abdominal, procedimentos endovasculares, fatores de risco, mortalidade, endoleak, complicações intraoperatórias, complicações pós-operatórias.

ABSTRACT

Objectives: To evaluate the relationship between clinical variables and aneurysm morphology with overall and gender-related mortality, endoleaks, and aneurysm-related reinterventions in-hospital and during the follow-up period.

Methods: Prospective cohort with 345 patients submitted to endovascular treatment of abdominal aortic aneurysm between 2013 and 2020.

Results: During the 30-day period, proximal neck calcification increased the risk for mortality (OR = 1.04, 95% CI 1.005–1.07, p = 0.024). A larger proximal neck diameter increased the risk for type 1A endoleak (OR = 1.18, 95% CI 1.02–1.38, p = 0.026). A larger left CIA diameter (OR = 1.07, 95% CI 1.01–1.12, p = 0.012) and the presence of type 1B endoleaks (OR = 16.03, 95% CI 1.84–139.98, p = 0.012) increased the risk for aneurysm-related reintervention. During the average follow-up period of 2.8 years, older age (OR = 1.04, 95% CI 1.01–1.08, p = 0.009), previous cerebrovascular events (OR = 2.62, 95% CI 1.19–5.73, p = 0.016), chronic obstructive pulmonary disease (OR = 2.19, 95% CI 1.02–4.70, p = 0.043), previous alcohol abuse (OR = 1.52, 95% CI 1.02–2.27, p = 0.039), and a higher proximal neck angle (OR = 1.01, 95% CI 1.003–1.03, p = 0.014) increased the risk for overall mortality. A larger right CIA diameter (OR = 1.05, 95% CI 1.01–1.09, p = 0.028) was a risk factor for developing type 1B endoleak. Larger left CIA diameter (OR = 1.05, 95% CI 1.009–1.10, p = 0.019) increased the aneurysm-related reinterventions. The risk factors for mortality in the survival analysis were older age, previous alcohol abuse, and atrial fibrillation. For male patients, previous alcohol abuse (HR = 1.43, 95% CI 1.02–2.01, p = 0.036) and larger left CIA diameter (HR = 1.03, 95% CI 1.005–1.06, p = 0.022) represented risk factors for mortality. For female patients mortality, current smoking (HR = 6.27, 95% CI 1.85–21.23, p = 0.003), acute myocardial infarction (HR = 9.99, 95%CI 1.44–69.32, p = 0.020), chronic obstructive pulmonary disease (HR = 9.00, 95% CI 2.11–38.37, p = 0.003), and previous alcohol abuse (HR = 4.29, 95% CI 1.39–13.23, p = 0.011) increased the mortality risk.

Conclusion: In EVAR patients, age, previous cerebrovascular events, previous alcohol abuse, chronic obstructive pulmonary disease, and atrial fibrillation were associated with mid-term mortality. The proximal neck calcification increased in-hospital mortality. Larger proximal and distal neck diameters were associated with endoleaks and reinterventions. Therefore, some morphologic characteristics of the

AAA, other than the maximum diameter, are important prognostic markers.
Key words: endovascular procedure, abdominal aortic aneurysm, iliac aneurysm, endoleaks, risk factors, mortality.

LIST OF TABLES

LIST OF CHARTS

LIST OF ABBREVIATION

AAA	Abdominal aortic aneurysm
AMI	Acute myocardial infarction
ASA	American Society of Anesthesiologists
CABG	Coronary artery bypass graft
CI	Confidence interval
CIA	Common iliac artery
CKD	Chronic kidney disease
COPD	Chronic obstructive pulmonary disease
CS	Calcium score
CTA	Computed tomography angiography
DICOM	Digital Imaging and Communications in Medicine
VTE	Venous thromboembolism
EIA	External iliac artery
ESVS	European Society for Vascular Surgery
EVAR	Endovascular aneurysm repair
ICU	Intensive Care Unit
IFU	Manufacturer's Instructions for Use
IRB	Internal Review Board
HR	Hazard ratio
HVD	Heart valvar disease
MAD	Maximum aneurysm diameter
NICE	National Institute for Health and Care Excellence
OR	Odds ratio
OSR	Open surgical repair
PTCA	Percutaneous transluminal coronary angioplasty
PAD	Peripheral artery disease
RCT	Randomized controlled trials
SAH	Systemic arterial hypertension
SD	Standard deviation
SUS	Sistema Único de Saúde (Brazilian Unified Health System)
UFMG	Universidade Federal de Minas Gerais

TABLE OF CONTENTS

1 INTRODUCTION

The abdominal aortic aneurysm (AAA) is a focal dilatation of the aorta greater than 3 cm or a 50% increase in its normal diameter and represents 80% of aortic aneurysms (KUIVANIEMI et al., 2015; SAKALIHASAN et al., 2018; ULLERY; HALLETT; FLEISCHMANN, 2018). Open surgical repair (OSR) was the only option for abdominal aortic aneurysm (AAA) until 1987 when Volodos performed the first endovascular aneurysm repair (EVAR) (IVANCEV; VOGELZANG, 2020). In 1991, Parodi published the first EVAR (NAVARRO; PROCÓPIO, 2021; TAKAYAMA; YAMANOUCHI, 2013).

Initially, EVAR was reserved for patients unfit for OSR and with suitable aortic morphology (POWELL et al., 2017). Nowadays, EVAR has become the first-choice treatment due to lower early-term surgical morbidity and mortality (from intraoperative to two years) and early hospital discharge (PARAVASTU et al., 2014; SUCKOW et al., 2018); however, mortality increases in the mid- and long-term (between two and six years), primarily due to reinterventions and endoleaks (YOKOYAMA; KUNO; TAKAGI, 2020). Endoleaks are the most common complication after EVAR, being the aneurysmal sac filling after the treatment (GOLZARIAN; MAES; SUN, 2005).

The recommendations for surgical treatment (OSR vs EVAR) are discordant. While the European Society for Vascular Surgery (ESVS) clinical practice guidelines recommend EVAR as preferred treatment in patients with suitable anatomy and a life expectancy longer than three years, the National Institute for Health and Care Excellence (NICE) guidelines suggests offering the OSR unless contraindicated by anesthetic risk or comorbidities (BRADBURY et al., 2020; WANHAINEN et al., 2019).

Several risk factors had been described for increased mortality post-EVAR (KHASHRAM et al., 2016). Aside from comorbidities, aortic morphology was inconsistently associated with higher mortality (BADERKHAN et al., 2016; MARQUES-RIOS; OLIVEIRA-PINTO; MANSILHA, 2018; OLIVEIRA et al., 2018, 2019a). Maximum aneurysm diameter (MAD), proximal neck diameter, aortic calcification and thrombus, and distal neck characteristics, such as diameter, tortuosity, and heavy calcification of iliac arteries, have been associated with poor post-EVAR outcomes (ABBRUZZESE et al., 2008; BANNAZADEH et al., 2017; MARQUES-RIOS; OLIVEIRA-PINTO; MANSILHA, 2018; OLIVEIRA et al., 2019a, 2019b; TELLES et al., 2016).

Between 40% and 60% of patients with AAA are considered anatomically unsuitable for EVAR (WANKEN et al., 2020). The manufacturer's instructions for use (IFU) of endovascular devices set morphologic limits for implanting and proximal and distal neck sealing (ZACHARIAS et al., 2016). Those limitations have been exceeded with the experience of surgeons, improvement of the devices, and the need to treat high-risk patients (KARATHANOS et al., 2020; ZACHARIAS et al., 2016). The indication for EVAR has broadened, and now more than 70% of AAA patients are treated using this technique (ANTONIOU et al., 2013).

Performing EVAR outside the IFUs may lead to higher endoleak rates, sac expansion, aortic rupture, and reinterventions, increasing long-term post-EVAR mortality compared to OSR (ANTONIOU et al., 2015; POWELL et al., 2017; SWEETING et al., 2017; ZACHARIAS et al., 2016). Most reports associate mortality with implant inside or outside the manufacturer's IFU (ABBRUZZESE et al., 2008; ANTONIOU et al., 2013; BADERKHAN et al., 2016; MARQUES-RIOS; OLIVEIRA-PINTO; MANSILHA, 2018; OLIVEIRA et al., 2018, 2019a).

2 OBJECTIVES

This study's primary objective is to:

1) evaluate the relationship between clinical and aortic aneurysm morphology variables vs. 30-day and follow-up mortality.

Secondary aims are:

2) to assess the role of clinical and morphologic variables vs. endoleak and aneurysm-related reintervention rates in the 30-day and follow-up periods;

3) to determine the risk factors for gender-related mortality; and

4) to establish the risk factors for surgical failure.

3 METHODS

This analysis was based on the Endolong Registry, a phase IV observational and prospective cohort study conducted in the city of Belo Horizonte (State of Minas Gerais, BR). It is listed by the Brazilian National Committee of Clinical Research (*Plataforma Brasil*) as "*Endolong (Acompanhamento a longo prazo das endopróteses de aorta). A avaliação prospectiva dos resultados a longo prazo do implante de endoprótese para correção de aneurisma de aorta".* It was approved by the Internal Review Board (IRB) of the Universidade Federal de Minas Gerais (UFMG) Hospital de Clínicas and Hospital Madre Teresa. In the first hospital, the enrollment started in September 2013 and is still ongoing. In the second, the enrollment was from September 2013 to May 2016.

The Endolong Registry objectives are to collect data and provide long-term information regarding safety, efficacy, mortality, and adverse events related to endovascular treatment of aortic aneurysms (all aortic segments) aiming at a ten-year follow-up. As of November 30, 2020, 668 patients were enrolled. The inclusion criteria for the Endolong Registry were indication for aortic endovascular treatment by the investigator and signed informed consent.

In the present study, the inclusion criteria were patients submitted to endovascular treatment of infrarenal abdominal aortic and/or iliac segments. Exclusion criteria were other aortic segments treated, absence of aortic morphology measurement data available from Digital Imaging and Communications in Medicine (DICOM) images, and lack of precise date of death or other data inconsistency.

Patients underwent preoperative evaluation, including physical examination, laboratory exams, and computed tomography angiography (CTA) data from DICOM images. All surgeries were performed under general anesthesia. Data regarding mortality, presence and type of endoleak, and reintervention were recorded.

It was recommended that the patients have an imaging exam at one-month post-op and thereafter at least one follow-up yearly. Most of patients had their imaging exam (CTA) in the first procedure in-hospital stay. The patients' clinical status, imaging, measurements, and major adverse events were recorded. Phone calls, consultations, and imaging by ultrasound or CTA were considered as follow-ups. If the patient had not a physical consultation yearly, a phone call or telegram were performed to contact. There was at least one attempt yearly to contact the patients if a presential evaluation were not possible.

The epidemiologic features were age, gender, ethnicity, and body mass index (BMI; kg/m^2). The evaluated ethnicities were White (or Caucasian), Black, Mulatto, and others (including Asian, Arabian, or unidentified).

The previous comorbidities and risk factors recorded at admission were: systemic arterial hypertension (SAH), smoking (current and previous), hyperlipidemia, obesity (BMI above 30 kg/m^2), heart disease, diabetes mellitus, acute myocardial infarction (AMI), cerebrovascular events (transient ischemic attack and stroke), cancer, chronic obstructive pulmonary disease (COPD), alcohol abuse (current and previous), erectile dysfunction (for males), peripheral artery disease (PAD), chronic kidney disease (CKD, pre and post-dialysis), coronary artery bypass graft (CABG), percutaneous transluminal coronary angioplasty (PTCA), heart valve disease (HVD), atrial fibrillation, and venous thromboembolism (VTE).

The recorded medicines in use were antihypertensive, statins, antiplatelets, antiarrhythmic, antidiabetic, and anticoagulants.

The anatomical variables included were maximum aneurysm diameter (MAD), proximal neck features (length, diameter, angulation, thrombus, calcification, and shape), the mean diameter of the right and left common iliac arteries (CIA), and the mean diameter of the right and left external iliac arteries (EIA).

Proximal neck length and diameter, MAD, and right and left CIA and EIA diameter were represented in millimeters. Proximal thrombus and calcification were represented by the percentage of circumference. Proximal neck angulation was expressed in degrees. For the proximal neck diameter, right and left CIA, and right and left EIA, the arithmetic mean was calculated based on those vessels' minimum and maximum diameters. A hostile proximal neck (outside the IFU) was defined as a length shorter than 10 mm, an angulation higher than 60 degrees, and the presence of more than 50% circumference calcification or thrombus.

It was considered a technical success if there was a proper deployment of the endograft with the absence of type 1 and 3 endoleaks, less than 30% stenosis (independently of the cause: kinking, extrinsic compression, or twisting), and absence of access complications (CHAIKOF et al., 2002).

Patients had a surgical failure if they had a persisting intraoperative type 1 or 3 endoleak, stenosis more than 30% (kinking, extrinsic compression, twisting, or residual peripheral artery disease in access arteries), access complications (acute arterial occlusion, pseudoaneurysm or infection), rupture, or death.

Five different devices brands were implanted: Endurant 2™ (Medtronic Inc, Santa Rosa, CA, USA), Excluder™ (W.L. Gore & Associates, Flagstaff, AZ, USA), Zenith™ (Cook Medical, Bloomington, IN, USA), Anaconda™ (Vascutek - Terumo Company, Inchinnan, Scotland, UK), and Incraft™ (Cordis, Cardinal Health Company, Dublin, Ireland).

An endoleak was defined as post-EVAR blood flow in the aneurysmal sac classified on a scale of 1 to 5 (GOLZARIAN; MAES; SUN, 2005; TAKAYAMA; YAMANOUCHI, 2013). For this analysis, only types 1A, 1B, and 3, which are closely correlated with proximal and distal landing zones, were evaluated in the section on endoleaks. Types 2, 4, and 5 endoleaks were excluded from this analysis because there is no specific anatomical correlation.

Reintervention was defined as any aneurysm-related intervention performed during the follow-up period. Aneurysm-related reinterventions were endoleak treatment (approached by embolization, placement of proximal or distal neck cuff, or extension), bleeding control, hematoma and abscess drainage, graft-limb or access-related acute arterial occlusion treatment (revascularization by thrombolysis, angioplasty, or bypass), removal of infected graft, arteriography, treatment of pseudoaneurysm, endograft angioplasty, or treatment of graft kinking.

The main outcomes were all-cause and gender-related mortality, endoleaks (all types), type 1A and type 1B endoleaks, endoleak 3, and aneurysm-related reintervention. Those results were observed during two periods: in-hospital (through 30 days after the first surgery) and follow-up (beyond 30-days after the first surgery) and in a survival curve analysis.

For descriptive statistical analysis, the data represented the absolute number of cases and proportions or means with standard deviations (±). For the continuous variables, normality was assumed according to the central limit theorem. For demographics, Fisher's exact test and Student's t-test were used. Logistic regression was used for in-hospital and follow-up results. Univariate and multivariate logistic regression were performed, and their results expressed by odds Ratio (OR). In the survival analysis, the log-rank test and Cox regression were also used. Unadjusted Kaplan-Meyer curves represented the all-cause and gender-related mortality. The relationship between variables was determined using Cox regression and characterized by hazard ratio (HR), with their respective 95% confidence intervals

(CIs). After univariate Cox regression, a multivariate Cox regression was performed. Variables with a p-value less than 0.1 in the univariate analysis were selected for multivariate analysis. Data and statistical analyses were performed using Stata® version 16 (StataCorp, College Station, Texas, USA). A p-value less than 0.05 was considered significant.

4 RESULTS

Of the 668 patients enrolled in the Endolong Registry, 323 were excluded because they had thoracic aneurysms (230 patients) or no available DICOM-CTA data (93 patients) for aortoiliac measurements. Three hundred and forty-five patients were selected for this analysis. Males represented 79.4% of the sample, with a male/female ratio of 3.9. White ethnicity was most prevalent (72.5%), with the remaining 25.8% being Black or Mulatto. There were no racial differences between genders. The overall mean age was 70.6 ± 8.8 years: for female patients, it was 69.7 ± 8.3 years, and for males, 70.9 ± 8.9 years (p-value = 0.312). The mean BMI was 25.2 ± 4.2 kg/m^2, with no differences between females and males (Table 1).

Table 1. Demographics, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	**Female n (%)**	**Male n (%)**	**p-value**
Age (years)**	70.6 ± 8.8	69.7 ± 8.3	70.9 ± 8.9	0.312
Gender	345 (100)	71 (20.6)	274 (79.4)	
Race$^\alpha$				0.230
White	250 (72.5)	47 (66.2)	203 (74.1)	
Black	36 (10.4)	12 (16.9)	24 (8.8)	
Mulatto	53 (15.4)	11 (15.5)	42 (15.3)	
Other	6 (1.7)	1 (1.4)	5 (1.8)	
BMI (kg/m^2)**	25.2 ± 4.2	25.5 ± 4.9	25.1 ± 4.1	0.492

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
$^\alpha$Fisher's exact test
**Student's t-test
*p-value<0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender
±: Standard deviation

The most prevalent comorbidities were SAH (77.4%), hyperlipidemia (45.4%), and smoking (65.3% and 28.1% for previous and current smokers, respectively). SAH and obesity were significantly more prevalent among women compared with the male patients (SAH 88.7% vs. 74.5%, p = 0.010; and obesity 47.8% vs. 33.3%, p = 0.034, respectively). The men had a higher prevalence of previous smoking (71.7% vs. 40%, p < 0.001) and AMI (4.8% vs. 5.6%, p = 0.046) (Table 2). The most common cancers were prostate, skin, lung, and throat.

Table 2. Comorbidities, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Systemic arterial hypertension	267 (77.4)	63 (88.7)	204 (74.5)	**0.010***
Previous smoking	162 (65.3)	20 (40)	142 (71.7)	**< 0.001***
Hyperlipidemia	156 (45.4)	33 (46.5)	123 (45.1)	0.849
Current smoking	97 (28.1)	21 (29.6)	76 (27.7)	0.768
Heart disease	81 (23.5)	14 (19.7)	67 (24.5)	0.437
Obesity	121 (36.3)	33 (47.8)	88 (33.3)	**0.034***
Diabetes mellitus	50 (14.5)	9 (12.7)	41 (14.9)	0.708
Acute myocardial infarction	44 (12.9)	4 (5.6)	40 (14.8)	**0.046***
Cerebrovascular events	42 (12.2)	11 (15.5)	31 (11.4)	0.415
Cancer	39 (11.3)	5 (7.0)	34 (12.4)	0.292
Chronic obstructive pulmonary disease	39 (11.3)	5 (7.0)	34 (12.4)	0.292
Previous alcohol abuse	38 (11.0)	4 (5.6)	34 (12.4)	0.136
Peripheral artery disease	33 (9.6)	7 (9.9)	26 (9.5)	1.00
Chronic kidney disease	36 (10.4)	6 (8.5)	30 (10.9)	0.666
Current alcohol abuse	26 (7.5)	5 (7.0)	21 (7.7)	1.00
Coronary artery bypass graft	20 (5.8)	1 (1.4)	19 (6.9)	0.089
Percutaneous transluminal coronary angioplasty	15 (4.4)	1 (1.4)	14 (5.1)	0.323
Valvar disease	10 (2.9)	4 (5.6)	6 (2.2)	0.225
Atrial fibrillation	8 (2.3)	3 (4.2)	5 (1.8)	0.214
Venous thromboembolism	9 (2.6)	3 (4.2)	6 (2.2)	0.398

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Fisher's exact test
**Student's t-test
*p-value<0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender
--: analysis was not possible due to the small number of cases (zero)

The most frequent medicines in use were antihypertensives (75.4%), statins (64.8%), and antiplatelets (53.9%). The women had a higher proportion of antihypertensive use than the male patients (87.3% vs. 72.3%, p = 0.008) (Table 3).

Table 3. Medications in use, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Antihypertensive drugs	260 (75.4)	62 (87.3)	198 (72.3)	**0.008***
Statins	224 (64.8)	48 (67.6)	176 (64.2)	0.676
Antiplatelets	186 (53.9)	39 (54.9)	147 (53.7)	0.894
Antiarrhythmic drugs	135 (39.1)	30 (42.3)	105 (38.3)	0.586
Antidiabetic medications	183 (53.0)	38 (53.5)	145 (52.9)	1.00
Anticoagulants	14 (4.1)	4 (5.6)	10 (3.7)	0.498

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Fisher's exact test
**Student's t-test

*p-value<0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender

The most frequent surgical indication for EVAR was aneurysm (97.9%) (Table 4), with isolated infrarenal aorta as the most frequent segment treated (68.7%). More than 25% of the patients had combined aortoiliac disease, and 5.2% had exclusive iliac disease (Table 5). There were no gender differences regarding disease or arterial segment treated.

Table 4. Diseases treated, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Aneurysm	338 (97.9)	71 (100)	267 (97.5)	0.352
Dissection	3 (0.9)	1 (1.4)	2 (0.7)	0.500
Mural hematoma	2 (0.6)	1 (1.4)	1 (0.4)	0.370
Aortic ulcer	9 (2.6)	0 (0)	9 (3.3)	0.213

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Fisher's exact test
*p-value < 0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender

Table 5. Arterial segment treated, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Infrarenal aorta	237 (68.7)	54 (76.1)	183 (66.8)	0.152
Iliac segment	18 (5.2)	2 (2.8)	16 (5.8)	0.386
Aortoiliac	88 (25.5)	15 (21.1)	73 (26.6)	0.365

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Fisher's exact test
*p-value < 0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender

The aortic morphology measurements are shown in Table 6. The most common proximal neck morphology was straight (73.6%), followed by tapered (18.2%) and reverse tapered (8.2%). There were no significant differences in the proximal neck shape between female and male patients (p = 0.851). More than 30% of patients (112 patients, 32.5%) were treated with a hostile proximal neck.

Women had a higher proximal neck angulation (42.8 ± 25.7º) than men (32.8 ± 23.4º, p = 0.002). Men had larger diameters of the proximal neck and iliac arteries. The proximal neck diameter in men was 22.8 ± 3.8 mm, while in women, it was 21.7 ± 4.2 mm (p = 0.031). The right CIA diameter in men was 18.9 ± 9.6 mm and 15.5 ± 6.6 mm (p = 0.005) in women. The left CIA diameter in men was 17.5 ± 8.3 mm and 14.0 ± 5.8 mm (p = 0.001) in women. The right EIA diameter in the men was 9.5 ± 2.4 mm and 8.7 ± 2.8 mm (p = 0.010) in women. Finally, the left EIA diameter in men was 9.5 ± 2.2 mm and 8.5 ± 1.8 mm (p < 0.001) in women (Table 6).

There were no significant differences between female and male patients in proximal neck length (26.7 ± 14.5 mm vs. 30.2 ± 18.9 mm, respectively; p = 0.151), percentage of proximal neck circumference with thrombus (female 7.9 ± 14.5% vs. male 10.5 ± 19.8%, p = 0.309), percentage of proximal neck circumference with calcification (female 4.8 ± 9.3% vs. male 7.3 ± 15.0%, p = 0.185), or MAD (female 58.8 ± 15.6 mm vs. male 58.9 ± 18.5 mm, p = 0.939) (Table 6).

Table 6. Preoperative aneurysm morphology, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General	Female	Male	p-value
Proximal neck length	29.5 ± 18.2	26.7 ± 14.5	30.2 ± 18.9	0.151
Proximal neck diameter	22.6 ± 3.9	21.7 ± 4.2	22.8 ± 3.8	**0.031***
Proximal neck angulation	34.9 ± 24.2	42.8 ± 25.7	32.8 ± 23.4	**0.002***
Proximal neck thrombus	9.9 ± 18.8	7.9 ± 14.5	10.5 ± 19.8	0.309
Proximal neck calcification	6.7 ± 14.0	4.8 ± 9.3	7.3 ± 15.0	0.185
Maximum aneurysm diameter	58.9 ± 17.9	58.8 ± 15.6	58.9 ± 18.5	0.939
Right common iliac artery diameter	18.2 ± 9.2	15.5 ± 6.6	18.9 ± 9.6	**0.005***
Left common iliac artery diameter	16.8 ± 7.9	14.0 ± 5.8	17.5 ± 8.3	**0.001***
Right external iliac artery diameter	9.4 ± 2.5	8.7 ± 2.8	9.5 ± 2.4	**0.010***
Left external iliac artery diameter	9.3 ± 2.1	8.5 ± 1.7	9.5 ± 2.2	**< 0.001***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Student's t-test
*p-value < 0.05
±: Standard deviation
Proximal neck length and diameter, maximum aneurysm diameter, right and left common iliac artery, and right and left external iliac artery in millimeters
Proximal neck angulation in degrees
Proximal neck thrombus and calcification in percentage of the circumference

The most common endograft used was Medtronic® Endurant 2. There were no significant differences between female and male patients in endograft used (p = 0.982) (Table 7).

Table 7 - Endograft's brand, general and by gender, in 343 patients submitted to EVAR in a Brazilian population between 2013- 2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Endurant 2™	265 (76.8)	55 (77.5)	201 (76.6)	0.982
Excluder™	43 (12.5)	10 (14.1)	33 (11.3)	
Zenith™	31 (8.99)	6 (8.5)	25 (9.1)	
Incraft™	3 (0.9)	--	3 (0.4)	
Anaconda™	3 (0.9)	--	3 (0.4)	

Data from Endolong Registry, organized by the author
EVAR: Endovascular Aneurysm Repair
Fisher's Exact Test
*p-value<0.05

4.1 30-DAY RESULTS

The primary technical success rate was 93.9%. Of 22 intraoperative events in 21 patients (surgical failure of 6.1%): seven patients had a persistent type 1A endoleak; four had a type 1B endoleak; two had a type 3 endoleak (this patient was submitted to a crossover bypass due to the impossibility of catheterization of the contralateral endograft limb); 4, finished the surgery with a kinking or prosthesis stenosis (one had an reintervention in 5 days and other, 10 days due to precocious arterial occlusion); three had arterial ruptures for which one (0.3%) underwent open surgical repair conversion, resulting in intraoperative death, and two (0.6%) were successfully treated endovascularly; one had acute arterial occlusion treated conservatively due to hemodynamic instability.

In the 30 days after surgery, there were seven additional cases of endoleaks: two type 1A, four type 1B, and one type 3 (Table 8).

Eight patients (2.3%) had intraoperative acute limb ischemia, all treated intraoperatively: two of these patients required a crossover femoro-femoral bypass due to limb graft occlusion; three patients had a successful embolectomy; one had angioplasty and stenting; one had a short common femoro-femoral bypass; and one patient was managed conservatively due to hemodynamic instability. There were also ten new cases of acute limb ischemia during the 30-day period, and all were promptly treated. No amputation was required, but one patient died (Table 8).

A regular bifurcated endograft was implanted in 93.6% of the patients, and 6.4% had an aortouniiliac endograft deployment associated with a femoro-femoral cross-over bypass. Sixty-three patients (25.7%) required an internal iliac artery approach: 46 patients required a unilateral iliac approach and seventeen required bilateral. The iliac interventions were coil embolization, iliac branched graft, and parallel covered stents (Table 8).

Table 8. Surgical results and associated procedures, general and by gender, in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Primary technical success	323 (93.9)	65 (91.5)	259 (94.5)	0.401
Persisting type 1A endoleak	7 (2.0)	3 (4.2)	4 (1.5)	0.156
Persisting type 1B endoleak	4 (1.2)	2 (2.8)	2 (0.7)	0.189
Persisting type 3 endoleak	1 (0.3)	0 (0)	1 (0.4)	1.00
Intraoperative rupture	3 (0.9)	0 (0)	3 (1.1)	1.00
Intraoperative arterial occlusion	8 (2.3)	2 (2.8)	6 (2.2)	0.670
Aortouniiliac endograft	22 (6.4)	3 (4.2)	19 (6.9)	0.587
Right internal iliac artery approach	23 (6.7)	3 (4.2)	20 (7.3)	0.436
Coil embolization	21 (6.1)	2 (2.8)	19 (7.3)	
Iliac branched graft	2 (0.6)	1 (1.4)	1 (0.4)	
Left internal iliac artery approach	23 (6.7)	4 (5.6)	19 (6.9)	1.00
Coil embolization	21 (6.1)	4 (5.6)	17 (6.2)	
Iliac branched graft	1 (0.3)	0 (0)	1 (0.4)	
Parallel stents	1 (0.3)	0 (0)	1 (0.4)	
Bilateral internal iliac artery approach	17 (4.9)	2 (2.8)	15 (5.5)	0.541

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Fisher's exact test
*p-value < 0.05
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender

The median ICU stay was one day (1–2 days, mean 2.0 ± 2.2 days) and the median in-hospital length of stay was four days (IQR 3–7 days, mean 7.2 ± 9.8 days).

In the univariate analysis, the risk factors for the intraoperative failure (6.1%) mentioned above were the presence of peripheral artery disease (PAD) (p=0.005), proximal neck diameter (p=0.035), and right (p=0.009) and left (p=0.014) EIA diameter. Previous smoking was a protective factor (p=0.041). There was a trend for cancer (p=0.071) and heart valve disease (p=0.086) (Table 9).

Table 9. Univariate logistic regression: risk factors for intraoperative surgical failure in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	95% CI	p-value
Demographics			
Age	0.97	0.92 – 1.02	0.217
Gender	1.59	0.59 – 4.27	0.354

Comorbidities			
Systemic arterial hypertension	0.93	0.33 – 2.63	0.892
Previous smoking	0.33	0.11 – 0.96	**0.041***
Hyperlipidemia	0.73	0.29 – 1.80	0.492
Current smoking	1.02	0.39 – 2.72	0.962
Heart disease	0.75	0.25 – 2.31	0.622
Obesity	0.79	0.29 – 2.16	0.658
Diabetes mellitus	0.98	0.28 – 3.47	0.978
Acute myocardial infarction	1.13	0.32 – 4.02	0.845
Cerebrovascular events	1.21	0.34 – 4.31	0.765
Cancer	2.67	0.92 – 7.73	0.071
Chronic obstructive pulmonary disease	0.38	0.05 – 2.88	0.347
Previous alcohol abuse	1.17	0.62 – 2.22	0.623
Peripheral artery disease	4.39	1.57 – 12.23	**0.005***
Chronic kidney disease	0.41	0.05 – 3.17	0.395
Current alcohol abuse	1.32	0.29 – 5.99	0.723
Coronary artery bypass graft	0.80	0.10 – 6.28	0.832
Percutaneous transluminal coronary angioplasty	--	--	--
Valvar disease	4.13	0.82 – 20.82	0.086
Atrial fibrillation	2.26	0.27 – 19.32	0.455
Venous thromboembolism	1.98	0.24 – 16.58	0.531
Anatomic features			
Proximal neck length	1.01	0.98 – 1.03	0.581
Proximal neck diameter	1.11	1.008 – 1.23	**0.035***
Proximal neck angulation	0.99	0.98 – 1.01	0.637
Proximal neck thrombus	1.001	0.98 – 1.03	0.931
Proximal neck calcification	1.02	0.99 – 1.04	0.135
Maximum aneurysm diameter	1.00	0.98 – 1.03	0.974
Right common iliac artery diameter	1.03	0.99 – 1.07	0.163
Left common iliac artery diameter	0.99	0.94 – 1.06	0.974
Right external iliac artery diameter	1.22	1.05 – 1.42	**0.009***
Left external iliac artery diameter	1.28	1.05 – 1.57	**0.014***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval
--: calculation was not possible due to the small number of cases (zero)

In the multivariate analysis, PAD was a risk factor (OR=16.71, 95% CI 3.68 – 75.89, p<0.001) and previous smoking, a protective factor (OR=0.18, 95% CI 0.05 – 0.65, p=0.009) (Table 10).

Table 10. Multivariate logistic regression: risk factors for surgical failure in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Previous smoking	0.18	0.05 – 0.65	**0.009***
Cancer	4.24	0.94 – 19.12	0.060
Peripheral artery disease	16.71	3.68 – 75.89	**<0.001***
Valvar disease	--	--	--
Proximal neck diameter	1.09	0.96 – 1.26	0.181
Right external iliac artery diameter	1.18	0.97 – 1.43	0.101
Left external iliac artery diameter	1.12	0.86 – 1.46	0.410

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval
--: calculation was not possible due to the small number of cases (zero)

4.1.1 30-day mortality

Nine patients (2.6%) died in the 30-day period: three intraoperative deaths and six during the 30-day period. The cause of all the intraoperative deaths was hemorrhagic shock due to iliac artery rupture.

The causes of the six postoperative in-hospital deaths were acute mesenteric ischemia, pneumonia, hemorrhagic stroke, respiratory insufficiency, acute limb ischemia, and acute endograft occlusion leading to acute limb ischemia.

Univariate logistic regression showed that the right (p = 0.012) and left (p = 0.045) CIA diameter were risk factors for 30-day mortality, as well as the left EIA diameter (p = 0.065) and proximal neck calcification (p = 0.093). There was no association of 30-day mortality with comorbidities or reinterventions (Table 11).

Table 11. Univariate logistic regression: risk factors for 30-day mortality in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	1.02	0.95–1.11	0.582
Gender	1.11	0.22–5.44	0.902
Comorbidities			
Systemic arterial hypertension	2.38	0.29–19.31	0.417
Previous smoking	--	--	--
Hyperlipidemia	0.59	0.15–2.42	0.468
Current smoking	2.09	0.55–7.95	0.280
Heart disease	--	--	--
Obesity	1.78	0.44–7.24	0.422
Diabetes mellitus	1.71	0.35–8.49	0.509
Acute myocardial infarction	0.84	0.10–6.88	0.871
Cerebrovascular events	0.89	0.11–7.35	0.919
Cancer	2.31	0.46–11.53	0.308
Chronic obstructive pulmonary disease	--	--	--
Previous alcohol abuse	1.54	0.69–3.45	0.291
Peripheral artery disease	2.80	0.56–14.08	0.211
Chronic kidney disease	--	--	--
Current alcohol abuse	--	--	--
Coronary artery bypass graft	--	--	--
Percutaneous transluminal coronary angioplasty	2.88	0.34–24.59	0.335
Valvar disease	4.51	0.51–40.00	0.176
Atrial fibrillation	--	--	--

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Venous thromboembolism	--	--	--
Anatomic features			
Proximal neck length	0.99	0.95–1.03	0.691
Proximal neck diameter	1.10	0.95–1.28	0.206
Proximal neck angulation	0.98	0.95–1.01	0.210
Proximal neck thrombus	1.01	0.98–1.04	0.580
Proximal neck calcification	1.03	0.99–1.06	0.093
Maximum aneurysm diameter	1.02	0.99–1.05	0.268
Right common iliac artery diameter	1.06	1.01–1.10	**0.012***
Left common iliac artery diameter	1.06	1.001–1.12	**0.045***
Right external iliac artery diameter	1.16	0.95–1.42	0.138
Left external iliac artery diameter	1.30	0.98–1.73	0.065
30-day endoleaks			
Endoleak – all types	--	--	--
Type 1A endoleak	--	--	--
Type 1B endoleak	--	--	--
Type 3 endoleak	--	--	--
Reintervention	1.98	0.24–16.58	0.531

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval
--: calculation was not possible due to the small number of cases (zero)

Multivariate analysis showed that only higher proximal neck calcification was a significant risk factor for 30-day mortality (OR = 1.04, 95% CI 1.005–1.07, p = 0.024) (Table 12).

Table 12. Multivariate logistic regression: risk factors for 30-day mortality in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Right common iliac artery diameter	1.04	0.99–1.11	0.144
Left common iliac artery diameter	1.03	0.94–1.12	0.571
Left external iliac artery diameter	1.23	0.88–1.71	0.229
Proximal neck calcification	1.04	1.003–1.07	**0.033***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.1.2 30-day endoleaks

There were twelve persistent cases of endoleaks after surgery (seven type 1A, four type 1B, and one type 3). Another seven additional cases of endoleaks were identified in the 30 days after surgery: two type 1A, four type 1B, and one type 3.

4.1.2.1 30-day type 1A endoleaks

Forty-one type 1A endoleaks were identified and treated intraoperatively. The approaches were re-accommodation with a complacent balloon (twelve cases), additional proximal neck cuff (twenty-three cases), additional cuff and stenting for renal artery (one case), proximal neck cuff plus limb extension (two cases), limb extension (two cases), and coil embolization (one case). Seven patients (2.0%) had a persistent type 1A endoleak at the end of surgery. There were two additional cases (0.6%) of type 1A endoleak in the first 30-days after surgery, totaling nine type 1A endoleaks (2.6%).

According to the univariate logistic regression, proximal neck diameter was a risk factor (p = 0.027) for 30-day type 1A endoleaks, but age was a protective factor (p = 0.029) (Table 13).

Table 13. Univariate logistic regression: risk factors for 30-day type 1A endoleak in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.93	0.87–0.99	**0.029***
Gender	1.97	0.48–8.08	0.346
Anatomic features			
Proximal neck length	1.005	0.97–1.04	0.788
Proximal neck diameter	1.17	1.02–1.34	**0.027***
Proximal neck angulation	1.01	0.99–1.04	0.298
Proximal neck thrombus	0.98	0.92–1.04	0.417
Proximal neck calcification	1.01	0.97–1.05	0.591
Maximum aneurysm diameter	1.01	0.98–1.05	0.526

Data from Endolong Registry, organized by the author
EVAR: Endovascular Aneurysm Repair
Logistic Regression
*p-value < 0.05
OR: Odds Ratio
95% CI: 95% Confidence Interval

Table 14 shows the multivariate analysis of risk factors for type 1A endoleak. It was found that larger proximal neck diameter (OR = 1.18, 95% CI 1.02–1.38, p = 0.026) was a risk factor for 30-day type 1A endoleak, and older age (OR = 0.93, 95% CI 0.87–0.99, p = 0.027) was a protective factor (Table 14).

Table 14. Multivariate logistic regression: risk factors for 30-day type 1A endoleak in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Age	0.93	0.87–0.99	**0.027***
Proximal neck diameter	1.18	1.02–1.38	**0.026***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.1.2.2 30-day type 1B endoleaks

There were thirteen patients with an intraoperative type 1B endoleak (3.8%). Four were treated with accommodation with a complacent balloon and seven with an additional limb-graft extension to EIA. Four (1.2%) patients had a persistent type 1B endoleak after the surgery, and there were four new cases (1.2%) in the 30 days after surgery. There were no risk factors for 30-day type 1B endoleaks (eight cases, 2.33%) (Table 15).

Table 15. Univariate logistic regression: risk factors for 30-day type 1B endoleak in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.97	0.89–1.05	0.414
Gender	2.37	0.55–1.18	0.245
Anatomic features			
Maximum aneurysm diameter	0.99	0.96–1.04	0.811
Right common iliac artery diameter	1.02	0.96–1.09	0.453
Left common iliac artery diameter	0.95	0.85–1.08	0.445
Right external iliac artery diameter	0.99	0.74–1.31	0.929
Left external iliac artery diameter	1.01	0.72–1.41	0.959

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.1.2.3 30-day type 3 endoleaks

Four (1.2%) patients had a type 3 endoleak intraoperatively and were treated accordingly. One of these (0.3%) persisted after the surgery. One new case (0.3%)

was identified during the postoperative period. Both had reinterventions, the first after four and at 21 days, and the second at 34 days. The risk factors for type 3 endoleak were not studied due to the small number of cases.

4.1.3 30-day aneurysm-related reinterventions

Twenty-one patients (6.1%) underwent twenty-two reinterventions within 30-days after the first procedure: eight limb revascularizations due to acute limb ischemia, four surgeries for type 1A endoleaks, five for type 1B endoleaks, two for access site infection, one for a type 4 endoleak (angiography), one for pseudoaneurysm, and one endograft kinking.

In the univariate analysis, the risk factors for 30-day reintervention were diameter of left CIA (p = 0.007) and EIA (p = 0.037), 30-day endoleaks (all types, p < 0.001), 30-day type 1A endoleaks (p = 0.004), and 30-day type 1B endoleaks (p < 0.001), with a trend for proximal neck angulation (p = 0.099) and diameter of right CIA (p = 0.066) to be risk factors (Table 16).

Table 16. Univariate logistic regression: risk factors for 30-day reintervention in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.98	0.94–1.03	0.534
Gender	1.22	0.43–3.46	0.706
Anatomic features			
Proximal neck length	0.99	0.97–1.02	0.747
Proximal neck diameter	1.01	0.90–1.13	0.839
Proximal neck angulation	1.02	0.99–1.03	0.099
Proximal neck thrombus	0.99	0.96–1.02	0.359
Proximal neck calcification	0.97	0.93–1.02	0.307
Maximum aneurysm diameter	1.01	0.98–1.03	0.656
Right common iliac artery diameter	1.03	0.99–1.07	0.066
Left common iliac artery diameter	1.06	1.02–1.10	**0.007***
Right external iliac artery diameter	1.06	0.89–1.25	0.532
Left external iliac artery diameter	1.24	1.01–1.52	**0.037***
30-day endoleaks			
Endoleak – all types	14.59	5.51–38.64	**< 0.001***
Type 1A endoleak	8.83	2.04–38.23	**0.004***
Type 1B endoleak	33.44	7.34–152.40	**< 0.001***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

In the multivariate analysis, larger left CIA diameter (OR = 1.07, 95% CI 1.01–1.12, p = 0.012) and the presence of 30-day type 1B endoleaks (OR = 16.03, 95% CI 1.84–139.98, p = 0.012) were risk factors for 30-day reinterventions (Table 17).

Table 17. Multivariate logistic regression: risk factors for 30-day reintervention in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Proximal neck angulation	1.01	0.99–1.03	0.258
Right common iliac artery diameter	1.01	0.96–1.07	0.722
Left common iliac artery diameter	1.07	1.01–1.12	**0.012***
Left external iliac artery diameter	1.13	0.87–1.47	0.371
30-day endoleaks (all types)	4.41	0.88–22.16	0.071
30-day type 1A endoleaks	3.33	0.39–28.21	0.271
30-day type 1B endoleaks	16.03	1.84–139.98	**0.012***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.2 FOLLOW-UP RESULTS

The mean follow-up time was 2.84 years (±2.03 years, median 2.46 years, IQR 0.008–7.17 years), ranging from 0 (intraoperative death) to 9.21 years and 11.0 deaths per 100 person-years (95% CI 9.11–13.29) in a total of 989.35 person-years. During the follow-up period, 336 patients were evaluated, once nine (2.6%) died within thirty days after the first surgery. One hundred thirty-seven patients (39.7%) ended the follow-up (November 30th, 2020). There was no difference in the loss of follow-up between gender (log-rank test = 0.936). There was a mean of five follow-ups per patient (±5, median 4 follow-ups, IQR 2–8), ranging from 0 (intraoperative death) to 33. There was no difference between gender

4.2.1 Follow-up mortality

One hundred deaths occurred during the follow-up (29.8%). The most commonly known causes of death were infection (20.2%), stroke (11.1%), AMI (10.1%), and aneurysm-related causes (5.88%). The aneurysm-related causes of death were rupture, graft infection, acute limb ischemia, and, in one case, reintervention in a ruptured thoracoabdominal aneurismal progression.

In the univariate analysis, the clinical risk factors for all-cause mortality were age (p = 0.005), heart disease (p = 0.029), cerebrovascular events (p = 0.038), COPD (p = 0.007), previous alcohol abuse (p = 0.045), and atrial fibrillation (p = 0.008). There was also a trend for AMI (p = 0.067) and cancer (p = 0.061) to be risk factors (Table 17).

The univariate analysis also found that proximal neck diameter (p = 0.046) and angulation (p = 0.024) were morphological risk factors for mortality during the follow-up (Table 18).

Table 18. Univariate logistic regression: risk factors for follow-up all-cause mortality in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	1.04	1.01–1.07	**0.005***
Gender	1.23	0.70–2.17	0.467
Comorbidities			
Systemic arterial hypertension	1.39	0.78–2.48	0.267
Previous smoking	1.45	0.79–2.62	0.225
Hyperlipidemia	0.86	0.53–1.37	0.522
Current smoking	1.09	0.65–1.84	0.725
Heart disease	1.79	1.06–3.04	**0.029***
Obesity	0.85	0.51–1.39	0.508
Diabetes mellitus	1.09	0.56–2.10	0.808
Acute myocardial infarction	1.85	0.96–3.57	0.067
Cerebrovascular events	2.02	1.04–3.94	**0.038***
Cancer	1.95	0.97–3.92	0.061
Chronic obstructive pulmonary disease	2.53	1.28–4.99	**0.007***
Previous alcohol abuse	1.43	1.01–2.04	**0.045***
Peripheral artery disease	1.57	0.73–3.38	0.244
Chronic kidney disease	1.81	0.89–3.67	0.102
Current alcohol abuse	1.27	0.55–2.96	0.574
Coronary artery bypass graft	1.01	0.38–2.70	0.988
Percutaneous transluminal coronary angioplasty	1.82	0.61–5.39	0.280
Valvar disease	1.18	0.29–4.79	0.822
Atrial fibrillation	17.69	2.15–145.75	**0.008***
Venous thromboembolism	1.93	0.51–7.32	0.337
Anatomic features			
Proximal neck length	1.001	0.99–1.01	0.913
Proximal neck diameter	1.06	1.002–1.13	**0.046***
Proximal neck angulation	1.01	1.002–1.02	**0.024***
Proximal neck thrombus	1.008	0.99–1.02	0.201
Proximal neck calcification	1.008	0.99–1.03	0.361
Maximum aneurysm diameter	1.009	0.99–1.02	0.185
Right common iliac artery diameter	1.001	0.98–1.03	0.912
Left common iliac artery diameter	1.02	0.99–1.05	0.141
Right external iliac artery diameter	1.006	0.92–1.11	0.897
Left external iliac artery diameter	0.99	0.89–1.11	0.889

Follow-up endoleaks			
Endoleak – all types	1.2	0.54–2.67	0.654
Type 1A endoleak	2.45	0.77–7.78	0.129
Type 1B endoleak	0.58	0.16–2.09	0.403
Type 3 endoleak	2.37	0.15–38.33	0.542
Aneurysm-related Reintervention	1.62	0.86–3.02	0.138

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

Table 19 shows the results of the multivariate analysis of risk factors for all-cause mortality: which included older age (OR = 1.04, 95% CI 1.01–1.08, p = 0.009), previous cerebrovascular events (OR = 2.62, 95% CI 1.19–5.73, p = 0.016), COPD (OR = 2.19, 95% CI 1.02–4.70, p = 0.043), previous alcohol abuse (OR = 1.52, 95% CI 1.02–2.27, p = 0.039), atrial fibrillation (OR = 27.09, 95% CI 2.96–248.04, p = 0.003), and higher proximal neck angulation (OR = 1.01, 95% CI 1.003–1.03, p = 0.014) (Table 19).

Table 19. Multivariate logistic regression: risk factors for all-cause mortality during the follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Age	1.04	1.01–1.08	**0.009***
Heart disease	1.18	0.52–2.65	0.682
Acute myocardial infarction	1.69	0.64–4.51	0.289
Cerebrovascular events	2.62	1.19–5.73	**0.016***
Cancer	1.99	0.91–4.38	0.087
Chronic obstructive pulmonary disease	2.19	1.02–4.70	**0.043***
Previous alcohol abuse	1.52	1.02–2.27	**0.039***
Atrial fibrillation	27.09	2.96–248.04	**0.003***
Proximal neck diameter	1.06	0.99–1.14	0.088
Proximal neck angulation	1.01	1.003–1.03	**0.014***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.2.2 Endoleaks during follow-up

In the follow-up period, thirty patients had a new endoleak (8.9%): twelve patients (3.6%) with type 1A, fifteen (4.5%) with type 1B, six (1.7%) with type 2, and two (0.6%) with type 3. There was no type 5 endoleak during the follow-up. One patient had an unknown endoleak type, and an angiography diagnosed it as a type 4.

The risk factors for all types of endoleaks at univariate analysis were proximal neck length (p = 0.014), right CIA diameter (p = 0.007), and right (p = 0.001) and left EIA diameter (p = 0.001) (Table 20). In the multivariate analysis, there were no risk factors for endoleaks (all types) (Table 21).

Table 20. Univariate logistic regression: risk factors for endoleaks (all types) during follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.98	0.94–1.02	0.273
Gender	0.96	0.38–2.46	0.939
Anatomic features			
Proximal neck length	1.02	1.004–1.04	**0.014***
Proximal neck diameter	1.04	0.95–1.14	0.400
Proximal neck angulation	1.01	0.99–1.03	0.120
Proximal neck thrombus	0.99	0.97–1.02	0.676
Proximal neck calcification	0.99	0.96–1.03	0.724
Maximum aneurysm diameter	1.008	0.99–1.03	0.446
Right common iliac artery diameter	1.04	1.01–1.08	**0.007***
Left common iliac artery diameter	1.03	0.99–1.07	0.124
Right external iliac artery diameter	1.31	1.12–1.53	**0.001***
Left external iliac artery diameter	1.39	1.15–1.67	**0.001***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

Table 21. Multivariate logistic regression: risk factors for endoleaks (all types) during follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Proximal neck length	1.02	0.99–1.03	0.090
Right common iliac artery diameter	1.02	0.98–1.06	0.269
Right external iliac artery diameter	1.16	0.95–1.41	0.151
Left external iliac artery diameter	1.15	0.89–1.49	0.282

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.2.2.1 Type 1A endoleaks in follow-up

In the univariate analysis, there was a trend for age (p = 0.090) to be a risk factor for type 1A endoleak in the follow-up (Table 22).

Table 22. Univariate logistic regression: risk factors for type 1A endoleak during the follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	1.06	0.99–1.14	0.090
Gender	1.99	0.58–6.82	0.272
Anatomic features			
Proximal neck length	1.01	0.98–1.04	0.416
Proximal neck diameter	0.95	0.81–1.11	0.488
Proximal neck angulation	1.01	0.99–1.03	0.434
Proximal neck thrombus	0.99	0.95–1.03	0.498
Proximal neck calcification	0.99	0.96–1.04	0.969
Maximum aneurysm diameter	0.99	0.96–1.03	0.813

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.2.2.2 Type 1B endoleaks in follow-up

The univariate analysis identified age as a protective factor (p = 0.005) for type 1B endoleaks during the follow-up. The right CIA diameter (p = 0.005) and the left EIA diameter (p = 0.037) were morphological risk factors, with a trend for the right EIA diameter (p = 0.051) to be a risk factor (Table 23).

Table 23. Univariate logistic regression: risk factors for type 1B endoleak during the follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.93	0.88–0.98	**0.005***
Gender	0.97	0.26–3.52	0.958
Anatomic features			
Maximum aneurysm diameter	1.01	0.99–1.04	0.359
Right common iliac artery diameter	1.05	1.02–1.09	**0.005***
Left common iliac artery diameter	1.03	0.97–1.08	0.320
Right external iliac artery diameter	1.18	0.99–1.40	0.051
Left external iliac artery diameter	1.29	1.02–1.65	**0.037***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

The multivariate analysis demonstrated that a larger right CIA diameter (OR =

1.05, 95% CI 1.01–1.09, p = 0.028) was a risk factor for type 1B endoleaks during the follow-up. On the other hand, older age (OR = 0.92, 95% CI 0.87–0.98, p = 0.007) was protective factor (Table 24).

Table 24. Multivariate logistic regression: risk factors for type 1B endoleak during the follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Age	0.92	0.87–0.98	**0.007***
Right common iliac artery diameter	1.05	1.01–1.09	**0.028***
Right external iliac artery diameter	1.06	0.77–1.46	0.711
Left external iliac artery diameter	1.09	0.74–1.58	0.671

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.2.3 Aneurysm-related reinterventions during follow-up

During follow-up, there were 107 aneurysm-related reinterventions in 49 patients (14.6%). The causes for reintervention were type 1B endoleak (twenty cases), type 1A endoleak (seventeen cases), acute limb ischemia (graft limbs and arterial access, sixteen cases), angiography (sixteen cases), type 2 endoleaks (eleven cases), graft infection (eleven cases), aneurysm rupture (four cases), type 3 endoleak (two cases), thoracoabdominal aneurismal progression (two cases), peripheral artery disease (two cases due to chronic limb-threatening ischemia), three bypasses (femoro-femoral cross-over bypass due to access complications), embolectomy (one case), type 4 endoleak (one case), and access pseudoaneurysm correction (one case).

The univariate analysis demonstrated that the risk factors for aneurysm-related reintervention during the follow-up were proximal neck length (p = 0.035), right (p = 0.008) and left (p = 0.002) CIA diameter, right (p = 0.013) and left (p = 0.001) EIA diameter, the presence of endoleaks (any type, p < 0.001), and type 1A (p < 0.001) and 1B (p < 0.001) endoleaks. Age was a protective factor (p = 0.014) (Table 25).

Table 25. Univariate logistic regression: risk factors for aneurysm-related reintervention in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Logistic Regression		
	OR	**95% CI**	**p-value**
Demographics			
Age	0.96	0.93–0.99	**0.014***

Gender	1.14	0.55–2.37	0.720
Anatomic features			
Proximal neck length	1.02	1.001–1.03	**0.035***
Proximal neck diameter	1.05	0.98–1.13	0.166
Proximal neck angulation	1.008	0.99–1.02	0.225
Proximal neck thrombus	0.99	0.98–1.01	0.538
Proximal neck calcification	0.98	0.95–1.01	0.239
Maximum aneurysm diameter	1.007	0.99–1.02	0.432
Right common iliac artery diameter	1.04	1.009–1.07	**0.008***
Left common iliac artery diameter	1.05	1.02–1.09	**0.002***
Right external iliac artery diameter	1.17	1.03–1.32	**0.013***
Left external iliac artery diameter	1.31	1.12–1.54	**0.001***
Endoleak			
Endoleak – all types	79.98	25.70–248.88	**< 0.001***
Type 1A endoleak	13.80	3.98–47.90	**< 0.001***
Type 1B endoleak	114.4	14.59–896.59	**< 0.001***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

The multivariate analysis showed that older age was a protective factor for aneurysm-related reintervention during the follow-up (OR = 0.95, 95% CI 0.91–0.99, p = 0.038). The risk factors were larger left CIA diameter (OR = 1.05, 95% CI 1.009–1.10, p = 0.019) and the presence of any type of endoleak (OR = 55.39, 95% CI 5.61–546.89, p = 0.001) (Table 26).

Table 26. Multivariate logistic regression: risk factors for aneurysm-related reintervention during the follow-up in 336 patients submitted to EVAR in a Brazilian population, 2013–2020.

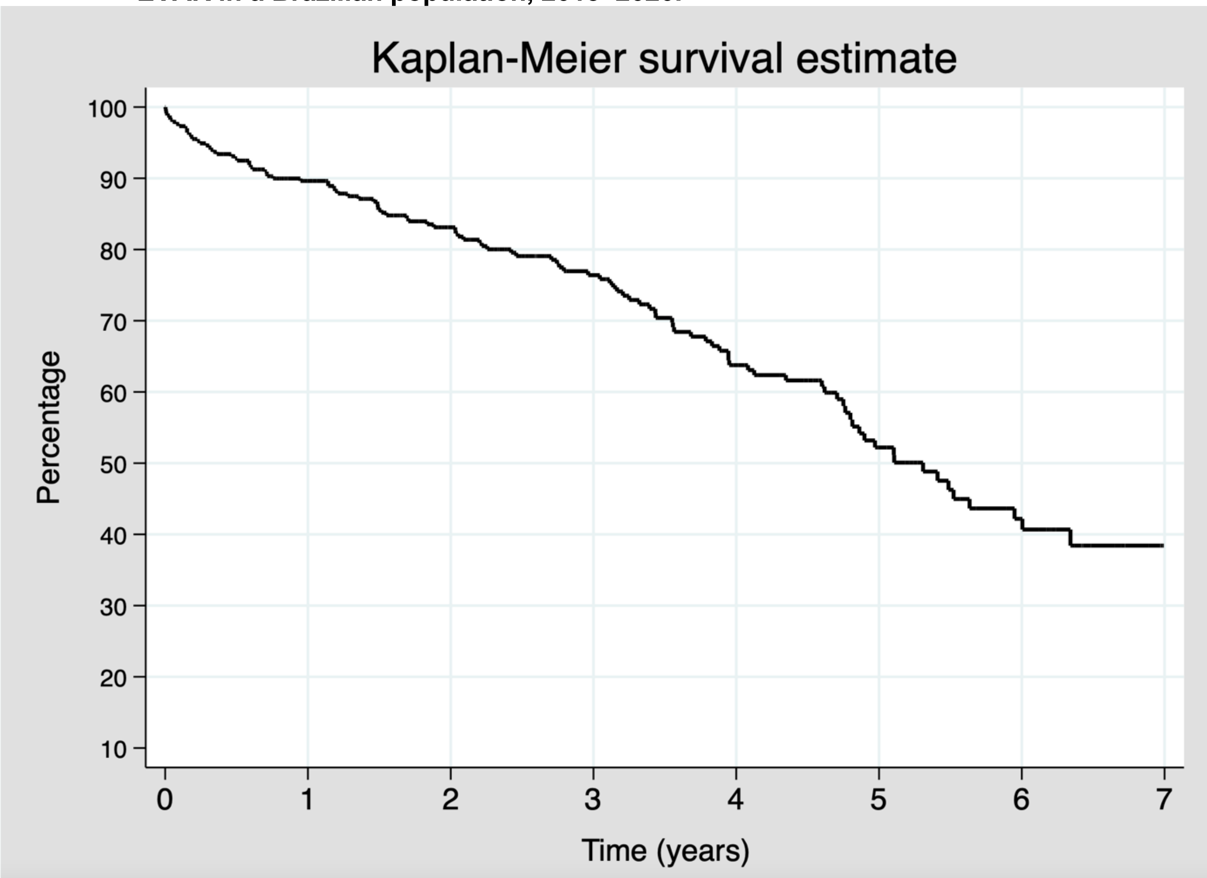
	Multivariate Logistic Regression		
	OR	**95% CI**	**p-value**
Age	0.95	0.91–0.99	**0.038***
Proximal neck length	1.007	0.98–1.03	0.520
Right common iliac artery diameter	0.99	0.95–1.05	0.969
Left common iliac artery diameter	1.05	1.009–1.10	**0.019***
Right external iliac artery diameter	0.88	0.73–1.07	0.198
Left external iliac artery diameter	1.22	0.93–1.61	0.151
Any type of endoleak during follow-up	55.39	5.61–546.89	**0.001***
Type 1A endoleak during follow-up	1.41	0.09–20.49	0.800
Type 1B endoleak during follow-up	2.37	0.11–49.73	0.579

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Logistic Regression
*p-value < 0.05
OR: Odds ratio
CI: Confidence interval

4.3 SURVIVAL ANALYSIS

The survival rate was 89.2% in the first year, decreasing to 76.5% in three years and 46.6% in six years (Chart 1). A Cox regression model was performed to analyze risk factors for all-cause mortality in the survival curve.

Chart 1. Survival curve (seven-year follow-up all-cause mortality) in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.



	First-year	Second year	Third year	Fourth year	Fifth year	Sixth year	Above six years
Patients at risk	345	267	201	144	101	59	36
Mortality	35	17	14	20	13	8	2
Censored	43	49	43	23	29	15	34
Survival (%)	89.2	82.9	76.5	64.9	55.2	46.6	42.5

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Unadjusted Kaplan-Meyer curve
Time in years

In the univariate analysis, age (p = 0.001), SAH (p = 0.014), previous smoking (p = 0.049), cerebrovascular events (p = 0.014), cancer (p = 0.002), COPD (p = 0.001), previous alcohol abuse (p = 0.004), and atrial fibrillation (p = 0.005) were risk factors for all-cause mortality, with a positive trend for AMI (p = 0.078) and venous thromboembolism (p = 0.072) (Table 27).

The univariate analysis also showed that proximal neck calcification was a significant risk factor for mortality (p = 0.047) (Table 27). The presence of endoleaks and aneurysm-related reintervention were not associated with all-cause mortality.

Table 27. Univariate Cox regression: comorbidities/risk factors at admission and all-cause mortality during the study period in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Cox Regression		
	HR	**95% CI**	**p-value**
Demographics			
Age	1.04	1.01–1.06	**0.001***
Gender	1.24	0.79–1.94	0.343
Comorbidities			
Systemic arterial hypertension	1.85	1.14–3.03	**0.014***
Previous smoking	1.66	1.003–2.75	**0.049***
Hyperlipidemia	0.85	0.58–1.25	0.418
Current smoking	1.09	0.72–1.64	0.697
Heart disease	1.36	0.90–2.06	0.143
Obesity	0.86	0.58–1.28	0.457
Diabetes mellitus	1.31	0.78–2.19	0.311
Acute myocardial infarction	1.56	0.95–2.57	0.078
Cerebrovascular events	1.86	1.13–3.06	**0.014***
Cancer	2.21	1.33–3.68	**0.002***
Chronic obstructive pulmonary disease	2.29	1.39–3.78	**0.001***
Previous alcohol abuse	1.45	1.12–1.86	**0.004***
Peripheral artery disease	1.36	0.78–2.39	0.283
Chronic kidney disease	1.38	0.80–2.38	0.246
Current alcohol abuse	0.95	0.48–1.89	0.895
Coronary artery bypass graft	0.71	0.31–1.62	0.416
Percutaneous transluminal coronary angioplasty	1.81	0.84–3.90	0.131
Valvar disease	0.55	0.17–1.73	0.303
Atrial fibrillation	3.03	1.41–6.52	**0.005***
Venous thromboembolism	2.52	0.92–6.89	0.072
Anatomic features			
Proximal neck length	1.001	0.99–1.01	0.903
Proximal neck diameter	1.03	0.99–1.08	0.160
Proximal neck angulation	1.005	0.99–1.01	0.261
Proximal neck thrombus	1.006	0.99–1.02	0.199
Proximal neck calcification	1.01	0.99–1.02	**0.047***
Maximum aneurysm diameter	1.006	0.99–1.02	0.287
Right common iliac artery diameter	1.005	0.99–1.02	0.618
Left common iliac artery diameter	1.02	0.99–1.04	0.125
Right external iliac artery diameter	1.005	0.93–1.09	0.907
Left external iliac artery diameter	0.95	0.86–1.05	0.292

Data from Endolong Registry, organized by the author
EVAR: Endovascular Aneurysm Repair
Cox regression
*p-value < 0.05
HR: Hazard Ratio
95% CI: 95% Confidence interval

Table 28 shows the survival curve's multivariate analysis of risk factors for all-cause mortality. The risk factors were older age (HR = 1.05, 95% CI 1.02–1.09, p = 0.002), previous alcohol abuse (HR = 1.51, 95% CI 1.09–2.09, p = 0.013), and atrial fibrillation (HR = 3.78, 95% CI 1.35–10.58, p = 0.011) (Table 28).

Table 28. Multivariate Cox regression: comorbidities/risk factors and all-cause mortality during the study period in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.

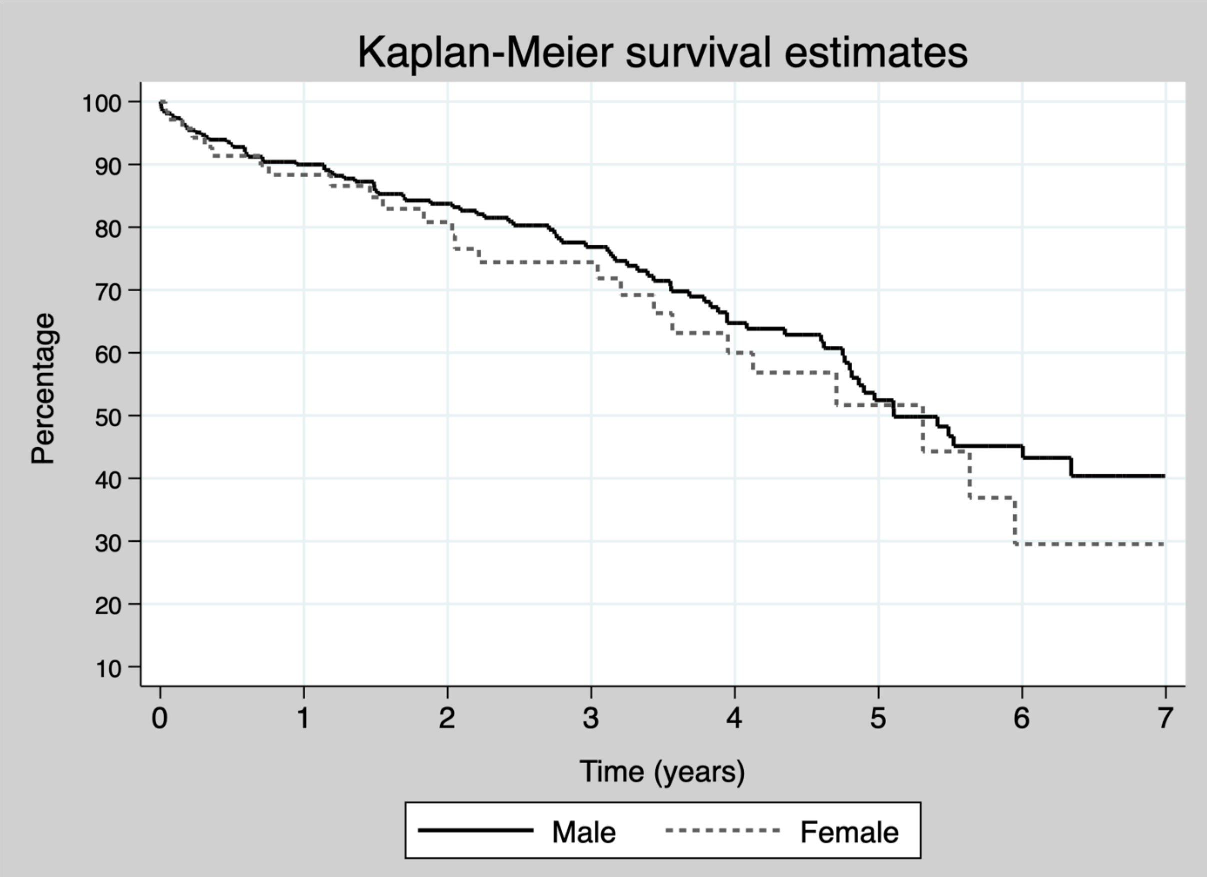
	Multivariate Cox Regression		
	HR	**95% CI**	**p-value**
Age	1.05	1.02–1.09	**0.002***
Systemic arterial hypertension	1.61	0.79–3.26	0.188
Previous smoking	1.47	0.85–2.53	0.165
Acute myocardial infarction	1.76	0.96–3.22	0.069
Cerebrovascular events	1.68	0.85–3.33	0.138
Cancer	1.32	0.65–2.68	0.440
Chronic obstructive pulmonary disease	1.96	0.99–3.85	0.050
Previous alcohol abuse	1.51	1.09–2.09	**0.013***
Atrial fibrillation	3.78	1.35–10.58	**0.011***
Venous thromboembolism	1.04	0.23–4.70	0.956
Proximal neck calcification	1.01	0.99–1.03	0.212

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Cox regression
*p-value < 0.05
HR: Hazard ratio
CI: Confidence interval

4.4 SURVIVAL ANALYSIS BY GENDER

A survival curve, log-rank test, and Cox regression analysis were performed by gender. The all-cause mortality survival curve between genders was similar (p = 0.342) (Chart 2).

Chart 2. Survival curve by gender: seven-year follow-up all-cause mortality in 345 patients submitted to EVAR in a Brazilian population, 2013–2020.



Data from Endolong Registry, organized by the author
Unadjusted Kaplan-Meyer curve
Log-rank test = 0.342
Time in years

For male patients, the univariate Cox regression identified age (p = 0.006), SAH (p = 0.021), previous smoking (p = 0.043), cancer (p = 0.004), COPD (p = 0.012), previous alcohol abuse (p = 0.018), erectile dysfunction (p = 0.031), chronic kidney disease (p = 0.048), and left CIA diameter (p = 0.039) as significant variables associated with all-cause mortality during the period of the study. There was a trend for the presence of endoleaks (any type, p = 0.086) (Table 29).

Table 29. Univariate Cox regression: comorbidities/risk factors and all-cause mortality in 274 male patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Cox Regression		
	HR	**95% CI**	**p-value**
Demographics			
Age	1.03	1.009–1.06	**0.006***
Comorbidities			
Systemic arterial hypertension	1.87	1.10–3.17	**0.021***
Previous smoking	1.89	1.02–3.49	**0.043***
Hyperlipidemia	0.96	0.62–1.48	0.840
Current smoking	0.89	0.54–1.45	0.633
Heart disease	1.38	0.86–2.19	0.179

	Univariate Cox Regression		
	HR	**95% CI**	**p-value**
Obesity	0.82	0.51–1.33	0.428
Diabetes mellitus	1.16	0.63–2.14	0.640
Acute myocardial infarction	1.48	0.86–2.56	0.159
Cerebrovascular events	1.58	0.84–2.99	0.157
Cancer	2.29	1.30–4.02	**0.004***
Chronic obstructive pulmonary disease	2.06	1.17–3.62	**0.012***
Previous alcohol abuse	1.40	1.06–1.86	**0.018***
Erectile dysfunction	1.81	1.05–3.09	**0.031***
Peripheral artery disease	1.41	0.75–2.67	0.287
Chronic kidney disease	1.76	1.005–3.08	**0.048***
Current alcohol abuse	1.01	0.47–2.19	0.976
Coronary artery bypass graft	0.64	0.26–1.57	0.327
Percutaneous transluminal coronary angioplasty	1.69	0.74–3.91	0.215
Valvar disease	0.77	0.19–3.16	0.722
Atrial fibrillation	2.17	0.79–5.93	0.132
Venous thromboembolism	0.96	0.13–6.97	0.969
Anatomic features			
Proximal neck length	0.99	0.99–1.01	0.755
Proximal neck diameter	1.04	0.99–1.09	0.157
Proximal neck angulation	1.003	0.99–1.01	0.564
Proximal neck thrombus	1.007	0.99–1.02	0.170
Proximal neck calcification	1.01	0.99–1.03	0.135
Maximum aneurysm diameter	1.009	0.99–1.02	0.161
Right common iliac artery diameter	1.008	0.99–1.03	0.441
Left common iliac artery diameter	1.02	1.001–1.05	**0.039***
Right external iliac artery diameter	1.04	0.96–1.14	0.336
Left external iliac artery diameter	0.98	0.87–1.09	0.695
Endoleak			
Endoleak – all types	0.56	0.29–1.08	0.086
Type 1A endoleak	0.63	0.19–1.99	0.429
Type 1B endoleak	0.75	0.30–1.84	0.525
Reintervention	0.79	0.47–1.35	0.390

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Cox regression
*p-value < 0.05
OR: Hazard ratio
CI: Confidence interval

The multivariate analysis showed that the risk factors for male all-cause mortality were previous alcohol abuse (HR = 1.43, 95% CI 1.02–2.01, p = 0.036) and larger left CIA diameter (HR = 1.03, 95% CI 1.005–1.06, p = 0.022). The presence of endoleaks (any type) was a protective factor for all-cause mortality in males (HR = 0.39, 95% CI 0.16–0.96, p = 0.040) (Table 30).

Table 30. Multivariate Cox regression: comorbidities/risk factors and all-cause mortality in 274 male patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Cox Regression		
	HR	**95% CI**	**p-value**
Age	1.02	0.98–1.06	0.337

	Multivariate Cox Regression		
	HR	**95% CI**	**p-value**
Systemic arterial hypertension	1.86	0.92–3.77	0.086
Previous smoking	1.35	0.68–2.70	0.393
Cancer	1.97	0.91–4.26	0.084
Chronic obstructive pulmonary disease	1.16	0.56–2.39	0.693
Previous alcohol abuse	1.43	1.02–2.01	**0.036***
Erectile dysfunction	1.85	0.93–3.67	0.078
Chronic kidney disease	1.29	0.62–2.69	0.489
Left common iliac artery diameter	1.03	1.005–1.06	**0.022***
Any type of endoleak	0.39	0.16–0.96	**0.040***

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Cox regression
*p-value < 0.05
HR: Hazard ratio
CI: Confidence interval

The univariate analysis for female patients identified COPD (p = 0.11), previous alcohol abuse (p = 0.016), atrial fibrillation (p = 0.005), and VTE (p = 0.007) as risk variables for mortality. There was a trend for age (p = 0.091), current smoking (p = 0.054), AMI (p = 0.054), cerebrovascular events (p = 0.052), proximal neck calcification (p = 0.082), all endoleaks (p = 0.065), and type 1B endoleaks (p = 0.092) to be risk factors. The right EIA diameter was a protective factor for female mortality (p = 0.040) (Table 31).

Table 31. Univariate Cox regression: Comorbidities/risk factors and all-cause mortality in 71 female patients submitted to EVAR in a Brazilian population, 2013–2020.

	Univariate Cox regression		
	HR	**95% CI**	**p-value**
Demographics			
Age	1.04	0.99–1.09	0.091
Comorbidities			
Systemic arterial hypertension	1.35	0.32–5.79	0.685
Previous smoking	1.27	0.46–3.52	0.641
Hyperlipidemia	0.57	0.25–1.29	0.175
Current smoking	2.23	0.99–5.06	0.054
Heart disease	1.42	0.56–3.59	0.460
Obesity	0.80	0.36–1.79	0.590
Diabetes mellitus	1.87	0.68–5.13	0.227
Acute myocardial infarction	3.44	0.98–12.10	0.054
Cerebrovascular events	2.31	0.99–5.39	0.052
Cancer	2.02	0.59–6.88	0.259
Chronic obstructive pulmonary disease	4.29	1.41–13.12	**0.011***
Previous alcohol abuse	2.13	1.15–3.96	**0.016***
Peripheral artery disease	1.19	0.35–4.04	0.775
Chronic kidney disease	--	--	--
Current alcohol abuse	0.76	0.18–3.26	0.714
Coronary artery bypass graft	3.28	0.43–24.96	0.251
Percutaneous transluminal coronary angioplasty	5.18	0.67–40.25	0.116
Valvar disease	0.26	0.03–2.01	0.197
Atrial fibrillation	6.33	1.76–22.77	**0.005***

	Univariate Cox regression		
	HR	**95% CI**	**p-value**
Venous thromboembolism	5.46	1.58–18.78	**0.007***
Anatomic features			
Proximal neck length	1.02	0.99–1.05	0.129
Proximal neck diameter	1.04	0.93–1.17	0.483
Proximal neck angulation	1.01	0.99–1.03	0.229
Proximal neck thrombus	1.001	0.97–1.03	0.968
Proximal neck calcification	1.03	0.99–1.07	0.082
Maximum aneurysm diameter	0.99	0.97–1.02	0.684
Right common iliac artery diameter	0.99	0.91–1.07	0.773
Left common iliac artery diameter	0.99	0.92–1.05	0.685
Right external iliac artery diameter	0.78	0.61–0.99	**0.040***
Left external iliac artery diameter	0.85	0.68–1.05	0.133
Endoleak			
Endoleak – all types	2.41	0.95–6.15	0.065
Type 1A endoleak	2.05	0.60–6.99	0.252
Type 1B endoleak	2.57	0.86–7.70	0.092
Reintervention	1.17	0.48–2.86	0.729

Data from Endolong Registry, organized by the author
EVAR: Endovascular aneurysm repair
Cox regression
*p-value < 0.05
OR: Hazard ratio
CI: Confidence interval
--: calculation was not possible due to the small number of cases (zero)

The multivariate analysis showed that current smoking (HR = 6.27, 95% CI 1.85–21.23, p = 0.003), AMI (HR = 9.99, 95% CI 1.44–69.32, p = 0.020), COPD (HR = 9.00, 95% CI 2.11–38.37, p = 0.003), and previous alcohol abuse (HR = 4.29, 95% CI 1.39–13.23, p = 0.011) were risk factors for female mortality. A larger right EIA diameter remained as a protective factor (HR = 0.63, 95% CI 0.45–0.89, p = 0.010) (Table 32).

Table 32. Multivariate Cox regression: Comorbidities/risk factors and all-cause mortality in 71 female patients submitted to EVAR in a Brazilian population, 2013–2020.

	Multivariate Cox Regression		
	HR	**95% CI**	**p-value**
Age	1.05	0.98–1.11	0.161
Current smoking	6.27	1.85–21.23	**0.003***
Acute myocardial infarction	9.99	1.44–69.32	**0.020***
Cerebrovascular events	0.87	0.24–3.19	0.839
Chronic obstructive pulmonary disease	9.00	2.11–38.37	**0.003***
Previous alcohol abuse	4.29	1.39–13.23	**0.011***
Atrial Fibrillation	3.71	0.31–45.10	0.303
Venous thromboembolism	1.44	0.16–13.09	0.746
Proximal neck calcification	1.03	0.97–1.09	0.370
Right external iliac artery diameter	0.63	0.45–0.89	**0.010***
Endoleak – all types	2.90	0.44–19.11	0.268
Type 1B endoleak	1.14	0.08–16.57	0.923

Data from Endolong Registry, organized by the author

EVAR: Endovascular aneurysm repair
Cox regression
*p-value < 0.05
HR: Hazard ratio
CI: Confidence interval

4.5 OVERALL RESULTS

The overall results for mortality, endoleaks, and aneurysm-related reinterventions are shown in Table 33.

Table 33. Main results, overall and by gender, in 345 patients submitted to EVAR during an average follow-up of 2.84 years (±2.03 years) in a Brazilian population, 2013–2020.

	General n (%)	Female n (%)	Male n (%)	p-value
Global results				
All-cause mortality	109 (31.6)	25 (35.2)	84 (30.7)	0.476
Endoleak - all types	46 (14.2)	10 (14.1)	36 (13.1)	0.845
Type 1A endoleaks	17 (4.9)	6 (8.5)	11 (4.0)	0.130
Type 1B endoleaks	21 (6.1)	6 (8.5)	15 (5.5)	0.401
Type 2 endoleaks	9 (2.6)	1 (1.4)	8 (2.9)	0.692
Type 3 endoleaks	3 (0.9)	--	3 (0.9)	1.00
Type 4 endoleaks	12 (3.5)	3 (4.2)	9 (3.3)	0.717
Aneurysm-related reintervention	62 (18.0)	14 (19.7)	48 (17.5)	0.729
30-day period				
30-day mortality	9 (2.6)	2 (2.8)	7 (2.6)	1.00
Endoleaks - all types	29 (8.4)	8 (11.3)	21 (7.7)	0.339
Type 1A endoleaks	9 (2.6)	3 (4.2)	6 (2.2)	0.398
Type 1B endoleaks	8 (2.3)	3 (4.2)	5 (1.8)	0.214
Type 2 endoleaks	3 (0.9)	--	3 (1.1)	1.00
Type 3 endoleaks	2 (0.6)	--	2 (0.7)	1.00
Type 4 endoleaks	12 (3.5)	3 (4.2)	9 (3.3)	0.717
Aneurysm-related reintervention	21 (6.1)	5 (7.0)	16 (5.8)	0.780
Follow-up				
All-cause mortality	100 (29.8)	23 (33.3)	77 (28.8)	0.464
Endoleaks - all types	30 (8.9)	6 (8.7)	24 (8.9)	1.00
Type 1A endoleaks	12 (3.6)	4 (5.8)	8 (3.0)	0.277
Type 1B endoleaks	15 (4.5)	3 (4.4)	12 (4.5)	1.00
Type 2 endoleaks	6 (1.7)	1 (1.4)	5 (1.8)	1.00
Type 3 endoleaks	2 (0.6)	--	2 (0.8)	1.00
Aneurysm-related reintervention	49 (14.6)	11 (15.9)	38 (14.2)	0.705

Data from Endolong Registry, organized by the author
EVAR: Endovascular Aneurysm Repair
30-day: events registered until 30-days after surgery
Follow-up: events registered above 30-days after the first surgery
Fisher's Exact Test
(%): Proportion for the general population is the absolute number of cases divided by 345
For female patients: female cases divided by the total number of females – 71 patients
For male patients: male cases divided by the total number of males – 274 patients
p-value: comparison between proportions of the female and male gender
--: calculation was not possible due to the small number of cases (zero)

5 DISCUSSION

The epidemiology of AAA and, consequently, the surgical indications and post-EVAR results vary worldwide and over time (LILJA; WANHAINEN; MANI, 2017). Most studies describe a population, mainly White male patients with a mean age of 74.6 years (BECQUEMIN et al., 2011; GREENHALGH et al., 2004; LEDERLE et al., 2009; LI et al., 2019; POWELL et al., 2017; PRINSSEN et al., 2004; SUCKOW et al., 2018; ZETTERVALL et al., 2016).

The present study had a 3.9 male/female ratio with one of the most significant proportions of female patients described. In the literature, the male/female ratio can be as high as nine-times, with most trials having around 6% to 13% female patients (BECQUEMIN et al., 2011; GREENHALGH et al., 2004; LEDERLE et al., 2009; LO et al., 2013; LO; SCHERMERHORN, 2016; POWELL et al., 2017; PRINSSEN et al., 2004; SCHERMERHORN et al., 2008; SWEET et al., 2011). A Schermerhorn et al. study, with a 45,660-patient cohort from the Medicare population, had one of the highest proportions of women, accounting for less than 20% of female patients (SCHERMERHORN et al., 2008). The high proportion of female patients is one of the distinguishing characteristics of this study, making it possible to evaluate specific risk factors for mortality for each gender.

This study also had one of the largest reported proportions of non-White patients (26.7%), most of them of Mulatto ethnicity. During the last thirty years of EVAR, the proportion of Black or other ethnicities has ranged between 6.5% and 12.8% (LEDERLE et al., 2009, 2019; YIN et al., 2019). Poor results were previously reported in Black patients (DEERY et al., 2018a; LEDERLE et al., 2009; YIN et al., 2019). The presence of a large proportion of non-White patients results from miscegenation, which is very common in the Brazilian population.

Despite results consistent with the available literature, this study had slight differences: higher proportions of females and Black and Mulatto ethnicity, younger mean age, and lower BMI. Those differences reflect Brazilian miscegenation, malnutrition, and probably later access to the health system, which might interfere with clinical and surgical results and lead to worse EVAR outcomes in terms of mortality, endoleaks, and reinterventions. Despite the lack of external validity, the higher incidence of female and Black/Mulatto patients brings new information for these subgroups.

This study had higher 30-day mortality (2.6%) when compared with studies in the literature, where the randomized controlled trials (RCTs) reported 30-day mortality between 0.2% and 1.8% (BECQUEMIN et al., 2011; INVESTIGATORS et al., 2010; LEDERLE et al., 2009; POWELL et al., 2017; PRINSSEN et al., 2004). Large cohorts, such as the Medicare and the American College of Surgeons' National Surgical Quality Improvement Program (NSQIP) studies, showed 1.2% and 1.3% (95% CI 1.2–1.5%) of 30-day mortality, respectively (MALAS et al., 2014; SCHERMERHORN et al., 2008). Over a recent 20-year period, Yin et al. were able to show a constant 1.2% 30-day mortality (DRURY et al., 2005; YIN et al., 2019). This higher mortality was related to several factors: differences in demographics, malnutrition, later access to the health system, poor control of comorbidities, and higher endoleak and reintervention rates in the 30-day period.

A higher proximal neck calcification was a risk factor for 30-day mortality. The evidence of the interference of proximal neck calcification in the 30-day mortality is unclear. According to Giles et al., peripheral artery disease was a significant risk factor for 30-day mortality (GILES et al., 2009). Kwon et al. found that a shaggy aorta increases the 30-day mortality (KWON et al., 2016). Kwon et al. defined a shaggy aorta as ≥75% of the aortic length, from the arch to the celiac trunk, and more than four millimeters thick with atherosclerotic plaque (KWON et al., 2016). Most of the EVAR patients did not meet these criteria for aortic calcification. TerBush et al. used a calcium score (CS) of 1 to 5 to classify aortic neck and iliac calcification and found that patients with a CS ≥ 3 had an increased risk for long-term mortality (TERBUSH et al., 2019).

Additionally, arterial calcification is a marker for atherosclerotic disease (ALEXOPOULOS; RAGGI, 2009). AAA is commonly associated with coronary and peripheral artery diseases (GOLLEDGE; NORMAN, 2010). Proximal neck calcification is also a marker for atherosclerotic disease; thus, it suggests increased cardiovascular risk (PATEL et al., 2018).

A proximal neck calcification of greater than 50% has previously been associated with an increased risk for intraoperative EVAR complications, such as type 1A endoleak and rupture (AHMED; GHOORAH; KUNADIAN, 2016; GONCALVES et al., 2015; SAMPAIO et al., 2004a). Most studies stratify proximal neck calcification in two categories: under or above 50% of circumference, which means that patients with 10%, 30%, or 50% of proximal neck calcification circumference will have a similar risk of complication. Using the one percent scale of proximal neck calcification circumference is possible to estimate an individual risk for each percentage. Moreover, the risk relationship is not linear, with an ascending curved shape: the risk is even higher as the proximal neck becomes more calcified.

This study's risk factors for follow-up mortality were older age, previous cerebrovascular events, COPD, previous alcohol abuse, atrial fibrillation, and proximal neck angulation. The patient's aging and clinical condition rather than the aneurysm morphology seems to be more significant in mid- and long-term mortality. Older age, female gender, higher American Society of Anesthesiologists score, coronary artery disease, cardiac failure, SAH, COPD, CKD, cerebrovascular disease, PAD, and diabetes were all previously associated with follow-up mortality (KHASHRAM et al., 2016; MARQUES-RIOS; OLIVEIRA-PINTO; MANSILHA, 2018).

There is no evidence of an effect of previous or current alcohol abuse on EVAR mortality. Alcohol abuse might lead to cirrhosis, and cirrhotic patients have higher post-EVAR mortality at two years compared with non-cirrhotic patients (77.4% vs. 97.8% survival, log-rank test p = 0.026) (MARROCCO-TRISCHITTA et al., 2011). Additionally, alcohol abuse is associated with higher overall mortality, being a risk factor for cancer, psychiatric disorders, and cirrhosis (REHM et al., 2003). It may also lead to malnutrition status and worse personal and hygiene care.

A more angulated proximal neck was a morphologic risk factor for mortality in follow-up. There is evidence that more than 60º of proximal neck angulation is related to proximal neck enlargement, long-term endograft migration, type 1A endoleak, sac enlargement, and reinterventions in post-EVAR follow-up (KARATHANOS et al., 2020; OLIVEIRA-PINTO et al., 2017; SEIKE et al., 2020); however, its relationship to follow-up mortality is uncertain. Oliveira et al. found no association, while Mathlouthi et al. found higher mortality at three years in patients with suprarenal neck angulation greater than 60º (75.8% of survival vs. 91.6% survival with < 60º suprarenal neck angulation, p = 0.006) (MATHLOUTHI et al., 2020; OLIVEIRA et al., 2021).

The role of proximal neck angulation in mortality is probably a consequence of complications of inadequate sealing. This study is the first to assess the proximal neck angulation as a continuous variable, showing that each one-degree increase in proximal neck angulation at the time of surgery increases the risk of death by 1%. A more angulated proximal neck also suggests a worse arteriopathy, increasing the complexity of the treatment.

This study's survival curve shows a result somewhat lower than the RCTs', whose survival rates were between 90% and 100% at the end of the first year, 80% to 90% at three years, and 70% to 75% at five years (PATEL et al., 2016; POWELL et al., 2017; TAKAGI et al., 2017). The observational study by Bastos Gonçalves et al. had higher mortality rates–89%, 78%, and 65%, respectively–which are similar with the results in this study's (GONÇALVES et al., 2016). The RCTs reflect an entirely different population, with patients that were clinically fit, had favorable anatomy, and were treated according to the IFUs. On the other hand, observational studies reflected more realistic results: patients with more comorbidities, hostile anatomy, and were treated outside the IFUs.

Like in follow-up mortality, similar risk factors were predictors for mortality in the survival curve: aging and the previous clinical condition of the patient were significant factors in post-EVAR life expectancy. The coherent results between the follow-up mortality and the survival analysis reinforce these results, as does a sensitivity analysis: independently of the statistical analysis, the results are similar.

There are conflicting results regarding the effect of gender on mortality and adverse events (ASH et al., 2020; ULUG et al., 2017). Few of the observational studies and none of the RCTs showed any differences between gender (LO; SCHERMERHORN, 2016; O'DONNELL et al., 2020; POWELL et al., 2017), while other observational studies found a positive correlation between female gender and higher 30-day and long-term mortality (LIU et al., 2019; POUNCEY et al., 2021; ULUG et al., 2017). Additionally, there is no evidence of specific gender risk factors for mortality in a survival curve. Despite significant differences in comorbidities and anatomy between male and female patients, the survival curve results were similar for both.

In the literature, the evidence on risk factors for male mortality post-EVAR is scarce. In this study, previous alcohol abuse and larger left CIA diameter were risk factors, and the presence of any type of endoleak was a protective factor for male mortality. For each one-millimeter increase in the left CIA diameter at surgery, the mortality risk for males goes up 3%. In this analysis, the left CIA diameter also represented a significant risk factor for follow-up reintervention. Larger arteries increased the risk for endoleaks and reintervention and might also be a factor for mortality.

The presence of endoleaks as a protective factor for male mortality was probably related to type 2 endoleaks. Despite the statistically similar proportions of endoleaks (all types) for male and female patients in follow-up, the absolute numbers of type 2 endoleaks were higher for men. Type 2 endoleaks are the most common in the literature and might be conservatively treated if there is no maximum aneurysm diameter enlargement.

The clinical risk factors for female mortality were current smoking, previous AMI, COPD, and previous alcohol abuse. Female patients had higher 30-day complication rates post-EVAR, such as cardiac, respiratory, and renal failure and limb ischemia (POUNCEY et al., 2021). In this analysis, a larger right EIA diameter represented a protective factor for female mortality. Female patients tended to have smaller access vessels and, consequently, a higher chance of access complications and the need for more complex treatment than males (DURAN et al., 2013; FERNANDEZ et al., 2009; SAMPAIO et al., 2004b). There are no previous reports on larger access arteries representing a protective factor in female mortality. For each one-millimeter enlargement of the right EIA diameter, the risk of female mortality decreases by 37%.

Endoleaks are the Achilles heel of EVAR. The presence of intraoperative endoleaks is not unusual, reaching as high as 23% (BLAKESLEE-CARTER; BECK; SPANGLER, 2020; MARREWIJK et al., 2002). An observational study by Sampaio et al. found 22.6% for type 1A, 20% for type 1B, and 4.2% for type 3 (SAMPAIO et al., 2009). Intraoperative type 1 and 3 endoleaks should be aggressively approached (SAMPAIO et al., 2009; SLAMBROUCK et al., 2020; SPANOS et al., 2019). Their intraoperative presence increases the chance for endoleaks in follow-up, and their persistence increases the chance for reintervention in the follow-up (SAMPAIO et al., 2009).

A larger proximal neck diameter represented a risk factor for type 1A endoleaks within the 30-day period. For each one-millimeter increase in the proximal neck diameter, the risk for endoleaks increases by 1.18-times. There is a close relationship between proximal neck morphology and the development of a type 1A endoleak, especially proximal neck diameter, length, shape, angulation, and endograft overlap and oversize (DINGEMANS et al., 2016; MAJOR et al., 2021; SLAMBROUCK et al., 2020). The presence of a proximal neck outside manufacturer IFUs is a strong predictor for type 1A endoleaks; patients within the IFUs had a 7% rate of type 1 endoleak in the 30-day period compared with patients outside the IFUs, who had 18% ($p = 0.0002$) (ABURAHMA et al., 2016, 2018). More than 30% of patients had an outside IFU proximal neck condition in this analysis. A challenging proximal neck (outside IFU) and larger proximal neck diameter led to a higher incidence of type 1A endoleaks in the 30-day period.

The incidence of endoleaks (all types) at follow-up ranges between 20% and 40%, with type 2 being the most common type (POWELL et al., 2017; ZHOU et al., 2014). In this study, type 1 endoleak was the most common. The higher incidence of type 1 was associated with a lack of diagnosis of type 2 endoleaks rather than its absence.

In EVAR, the iliac anatomy is decisive for endograft navigation and distal sealing (GALLITTO et al., 2017; KANG et al., 2020; SIRIGNANO et al., 2019). The incidence of type 1B endoleaks is directly dependent on the distal landing zone, ranging from 2.3% to 17% (GRAY et al., 2017; GRAY; GAWENDA, 2014; MASCOLI et al., 2019; WANG et al., 2018). A larger right CIA diameter was a risk factor for the development of type 1B endoleaks in follow-up. The risk increases for each millimeter of the right CIA diameter enlargement. Elderly and severely ill patients might benefit from simpler techniques (such as bell-bottom). In contrast, younger patients might benefit from more complex techniques depending on the risk of developing a type 1B endoleak at follow-up.

In this analysis, older age was a protective factor for type 1A endoleaks in the 30-day period and for type 1B endoleaks in follow-up. The literature reports higher reintervention rates and poorer survival rates for older patients (GILES et al., 2011). This protective effect of older age might reflect a selection bias. In the present study, in patients above 80 years old, there were no cases of type 1A endoleak in the 30-day period and one event for type 1B endoleak in the follow-up. Patients above 80 years were probably selected for EVAR in this analysis because they had low surgical risk and favorable anatomy, which could lead to a statistical protective effect.

The incidence of 30-day reintervention ranged between 3.3% and 6% and was directly dependent on intraoperative complications, such as: endoleaks, rupture, and limb ischemia (DEERY et al., 2018b; MOTTE et al., 2013; SIRIGNANO et al., 2016, 2018). The risk factors for 30-day reintervention were proximal neck angulation > 60 degrees, proximal neck length < 10 mm, and reversed taper (ABURAHMA et al., 2016, 2018). The incidence of 30-day reinterventions in the present study was higher than in the literature, and the risk factors for 30-day reintervention were a larger left CIA diameter and 30-day type 1B endoleaks.

At follow-up, the aneurism-related reintervention rates can be as high as 29.6% and are closely related to the presence of endoleaks (BRUIN et al., 2010; DINGEMANS et al., 2016; GERAEDTS et al., 2021; KARTHIKESALINGAM et al., 2010; LI et al., 2019; WANKEN et al., 2020). In this study, endoleaks (all types) were the most frequent cause (47.7%) and represented a risk factor for aneurysm-related reintervention.

A larger left CIA diameter was a predictor for aneurysm-related reintervention in both the 30-day and follow-up periods. For each millimeter larger, the risk for reintervention increases by 7% in the 30-day period and by 5% in the follow-up. The evidence of risk factors for follow-up reinterventions is highly heterogeneous (PATEL et al., 2017). Ohrlander et al. reported that larger CIA diameter and proximal neck angulation were independent risk factors for reintervention (OHRLANDER; DENCKER; ACOSTA, 2012).

Using the Chaikof et al. definition for primary success (CHAIKOF et al., 2002), this study's primary success rate of 93.9% is inferior to the literature, which ranged from 99.5% to 100% (ABURAHMA et al., 2016, 2018; BISDAS et al., 2014; SIRIGNANO et al., 2016, 2018; WANG et al., 2018). The worse result in the present study was due to the presence of type 1 endoleaks during the 30-day period, which was higher than reported in the literature. In the Brazilian Unified Health System (SUS), there are cost-related limitations on the use of endografts and sometimes, the treatment had to be staged, which increased the proportion of endoleaks and reinterventions in the 30-day period. This effect was easily seen in the higher incidence of type 1B endoleaks during the 30-day period (2.4% vs. 0.8% in previous reports) (SAMPAIO et al., 2009), as well as a higher rate of reintervention (6.1% vs. reports ranging between 3.3% and 6%) (DEERY et al., 2018b; MOTTE et al., 2013; SIRIGNANO et al., 2016, 2018). Higher endoleak rates and the need for reintervention might account for the higher 30-day mortality (2.6% vs. 1.2%) (YIN et al., 2019).

The risk factor for intraoperative failure was PAD. PAD was cited as a risk factor for intraoperative complications (endoleaks, covering of target arteries, and dissection or rupture of access arteries) by Vacirca et al. (VACIRCA et al., 2019). According to Vacirca et al., a complex AAA anatomy increases the risk for additional intraoperative maneuvers and morbimortality (VACIRCA et al., 2019). The present study corroborates the finding of PAD as a risk factor for intraoperative failure.

There is no previous evidence regarding the protective effect of previous smoking in intraoperative EVAR failure. The previous smoking patients represented almost 50% of this study's sample, were significantly older than non-smoking patients, and had worse outcomes. Of the six cases of surgical failure in previous smoking patients, three of them were intraoperative deaths. The non-smoking patients were younger, and although they had a higher absolute number for surgical failure (9 cases), all of them were endoleaks.

The initial idea of this study was to propose a predictive model for EVAR mortality using continuous anatomical variables; however, there are several limitations to this idea. First, the pathophysiology of AAA is still not fully understood. Secondly, these patients have multiple and severe comorbidities, contributing to mortality. Finally, the aortic anatomy interferes with the surgical technique–the more complex the treatment, the higher the risk of complications. The post-EVAR mortality depends on the combination of several factors: the patient's clinical condition and life expectancy, surgical success, and management of surgical complications (CHAIKOF et al., 2018; PATEL et al., 2016; SPANOS et al., 2020; SWEETING et al., 2017).

There are several limitations in this study. As an observational study, there is a higher risk of selection and data collection biases. The use of an exclusive population compromises external validity and the applicability of results. Despite a large number of patients, the statistical analysis is underpowered because of the small number of events. The higher prevalence of patients from the SUS, who tend to be more severely ill and anatomically unfit, might also lead to selection bias, resulting in higher rates of intraoperative and long-term complications. Additionally, there was a high rate of loss of follow-up compromising the final results.

6 CONCLUSION

The risk factor for all-cause mortality was a higher proximal neck calcification in the 30-day period. Older age, previous cerebrovascular events, COPD, previous alcohol abuse, atrial fibrillation, and higher proximal neck angulation represented risk factors for overall mortality during the follow-up period.

The risk factors for mortality in the survival curve were older age, previous alcohol abuse, and atrial fibrillation. There were no differences between the genders in the survival analysis; however, the risk factors for mortality differed between them. Male patients had a higher mortality risk if they were previously alcohol abusers and had a larger diameter of the left CIA, while the presence of endoleaks (any type) was a protective factor. The risk factors for female mortality were current smoking, previous AMI, COPD, and previous alcohol abuse. A larger right EIA diameter was a protective factor for female mortality.

Regarding the risk factors for endoleaks, a larger proximal neck diameter was a risk factor for type 1A endoleak, while older age was a protective factor in the 30-day period. A larger right CIA diameter increased the chance for type 1B endoleaks in the follow-up period.

In the 30-day period, a larger left CIA diameter and the presence of type 1B endoleaks increased the risk for aneurysm-related reintervention. In the follow-up period, the presence of any type of endoleaks and patients with larger left CIA diameter increased the risk of aneurysm-related reintervention.

Peripheral artery disease was a risk factor for surgical failure, while previous smoking had a protective role.

Therefore, some morphologic characteristics of AAA, other than the maximum diameter, were important prognostic markers.

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