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5-year results on abdominal aortic aneurysm repair in a tertiary center: a benchmark analysis from the Portuguese registry

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ABSTRACT

INTRODUCTION: Solid registries are crucial for auditing outcomes and improving practices in aortic aneurysm (AAA) repair. Accordingly, the Portuguese Society for Vascular Surgery (SPACV) has implemented a national registry since 2019. We aimed to benchmark our results in the registry to identify discrepancies and improve practice.

METHODS: We compared data from the SPACV registry for consecutive patients undergoing aortic surgery at our center (cohort A) and nationwide (cohort B) from November 2019 to December 2024. We analyzed demographics, preoperative comorbidities, and AAA characteristics (extent, diameter, admission mode). The primary outcome was 30-day mortality. Secondary outcomes included 30-day stroke, 30-day cardiac events, renal failure, and bowel ischemia.

RESULTS: Two-thousand consecutive patients underwent surgery in cohort B, of which 402 were treated in group A (20.1%). Mean age was similar between the two cohorts (73.7±8.5 in A vs. 73.9±11.5 in B). Most patients were male (92.8% in A vs. 93.22% in B). 58.2% of aneurysms were infrarenal. Most procedures were elective (79.9% in A vs. 80.9% in B) and predominantly endovascular (75.1% in A vs. 72.95% in B). Preoperative diameter was 63.5±16 mm, significantly larger in urgent cases (74.7±21.81 vs. 60.7±12.8mm, $p < 0.001$). 30-day mortality in cohort A was 8.59%, in line with cohort B. Overall, 30-day mortality was significantly higher in urgent cases (31.25% vs 2.85%, $p < 0.001$). Cohort A 30-day rates for stroke, myocardial infarction, and bowel ischemia were 1.52%, 4.80%, and 4.04%, respectively. In cohort A, 30-day mortality was significantly associated with age (per 10-unit increase, OR 1.07, $p < 0.001$), urgent setting (OR 1.24, $p < 0.001$), and preoperative creatinine (per 10-unit increase, OR 1.001, $p = 0.006$). EVAR conferred a reduced mortality risk (OR 0.88, $p < 0.001$).

CONCLUSIONS: Auditing national registries promotes better AAA repair outcomes. Our center's EVAR rates and 30-day mortality align with current national and international practices. Real-world data helps identify mortality predictors and potential improvements for daily practice.

Keywords: abdominal aortic aneurysm; endovascular procedure; registries; mortality

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INTRODUCTION

Abdominal aortic aneurysms (AAA) represent a disease most frequently found in males over the age of 65. Indeed, its prevalence can reach from 1 to 5% in this population. Although there was a decline in the number of admissions, the incidence of death for ruptured AAA can still reach 10:100.000 cases.[1,2] Efforts have been made to thoroughly understand the disease's pathophysiology and the best treatment approach. Indeed, with current advances in endovascular technologies and a progressive shift towards endovascular approaches, there is an evergrowing interest in comparing the outcomes of open and endovascular repair, especially over the long term.[3-5]

To this matter, various societies strongly recommend that centers performing aortic surgery report their cases in harmonized prospective registries to allow for monitoring of practice and outcomes, as to audit short and long-term results on aortic aneurysm repair. Despite its established presence in Northern Europe for decades, as in Sweden (Swedvasc), reporting of vascular surgery outcomes was confined to single-center experiences in Portugal.[6] Since 2019, the Portuguese Society for Vascular Surgery has implemented such a national registry and recently published the results on the first 1000 reported infra-renal cases.[7,8] Five years after its implementation, we aim to benchmark our results against the national registry to identify discrepancies and ways to improve our practice.

METHODS

This benchmark study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement for cohort studies.[9]

Study design and inclusion criteria

This is an observational prospective study using data collected from the National Registry for Abdominal Aortic Surgery. This is a module of the Portuguese National Registry of Vascular Procedures (RNPV), implemented by the Portuguese Society of Vascular Surgery (SPACV).

This registry has collected preoperative, perioperative, and postoperative data since 2019 from consecutive patients who underwent abdominal aortic surgery across over 90% of vascular centers in Portugal, including all tertiary and university centers, with local ethics committee approval at all centers. Included patients were consecutive patients undergoing open or endovascular AAA repair, either on an elective or emergent setting, from November 2019 to December 2024 at the participating centers. In this study, we defined 2 groups for benchmarking purposes: group A refers to data from our center (Unidade Local de Saúde Santa Maria) and group B refers to the overall national registry. Patient-level data were available for the local cohort; in contrast, the national cohort was provided in an anonymized, aggregated format, limiting the scope of available covariates for further analysis.

Variables, definitions and data collection

Prospectively collected data for groups A and B were assessed, including demographic information, such as sex and age. Preoperative data regarding comorbidities was collected, including traditional cardiovascular and non-cardiovascular risk factors such as diabetes, ischemic heart disease, cerebrovascular disease, pulmonary disease, all of which were confirmed through electronic and physical medical records, or chronic kidney disease, the latter through preoperative creatinine levels (renal failure was established at a cut-off value of 1.5 mg/dL or higher). Regarding AAA, data were analyzed regarding treatment indication, anatomic characteristics (location and diameter in mm), type of intervention, and treatment setting (elective or emergent).

Study outcomes and statistical approach

The primary outcome was 30-day mortality. Secondary outcomes included 30-day stroke, myocardial infarction, respiratory failure or renal failure, including the need for hemodialysis, and bowel ischemia. Study outcomes were compared between pre-established groups A and B.

Continuous variables were presented as mean (standard deviation) if normally distributed and median (interquartile range) if not. Dichotomous and categorical variables were expressed in numbers (percentages). Two-sample t-test or Mann-Whitney test was used when comparing continuous variables, and Chi-Square/Fisher's exact test to compare dichotomous variables. Regarding the primary outcome in group A, univariate and multivariate analyses were performed to identify potential risk factors, namely age, sex, preoperative diameter, AAA extent, urgent setting, endovascular surgery, preoperative creatinine, and other comorbidities (diabetes, cerebrovascular disease, ischemic heart disease, pulmonary disease). In the multivariate analysis, only statistically significant covariates were retained in the logistic regression model. Crude and adjusted odds ratios (OR) for significant covariates were reported with 95% confidence intervals.

All analyses were considered statistically significant if a two-tailed p-value < 0.05 was observed. Statistical analysis was carried out using STATA version 16.1 (Statistics/Data analysis, StataCorp LLC, Texas, USA).

RESULTS

Two-thousand consecutive patients were operated on in Portugal during the registry period until December 2024, while 402 were treated in our center. This corresponded to 20.1% of all reported AAA surgeries performed nationwide.

Baseline characteristics

Baseline evaluation is presented in Table 1. The mean age at admission for group A was 73.7 ± 8.5 years, and most patients were male (92.8%), with no statistically significant differences compared to cohort B (mean age 73.9 ± 11.5 years, 93.22% male patients). 16.7% of all patients were diabetic, and 30.1% had a cardiac condition, of which 52.8% reported previous myocardial infarction.

Table 1. Baseline characteristics

	Cohort A (n=402)
Age (years)	73.7 ± 8.5
Male sex	373 (92.8%)
ASA classification	
- II	12 (3.0%)
- III	307 (76.4%)
- IV	83 (83 (20.6%)
Chronic kidney disease	75 (30.15%)
Diabetes	67 (16.67%)
Cerebrovascular disease	39 (9.70%)
Any heart disease	121 (30.10%)
Myocardial infarction	59 (14.68%)
Pulmonary disease	96 (23.88%)
Aneurysm extent	
- Infrarenal	234 (58.2%)
- Isolated iliac	22 (5.5%)
- Juxtarenal	77 (19.2%)
- Pararenal	20 (5.0%)
- Thoracoabdominal	49 (12.1%)

Continuous variables in mean ± SD; proportions in absolute values and overall percentages

AAA characteristics and interventions

In cohort A, 58.2% of the aneurysms were infrarenal. The preoperative diameter was 63.5 ± 16 mm, with significantly larger diameters in urgent cases (74.7 ± 21.81 vs. 60.7 ± 12.8, p < 0.001). Patients underwent surgery due to increased aortic diameter in 68.33% of cases (Figure 1). Between 2020 and 2024, aortic diameter was also the main indication for surgery in 66.52% of patients in cohort B, with no statistically significant difference between the cohorts (p = 0.46). Further characterization by graft configuration is shown in Figure 2.

Figure 1. Treatment indications for AAA surgery (cohort A)

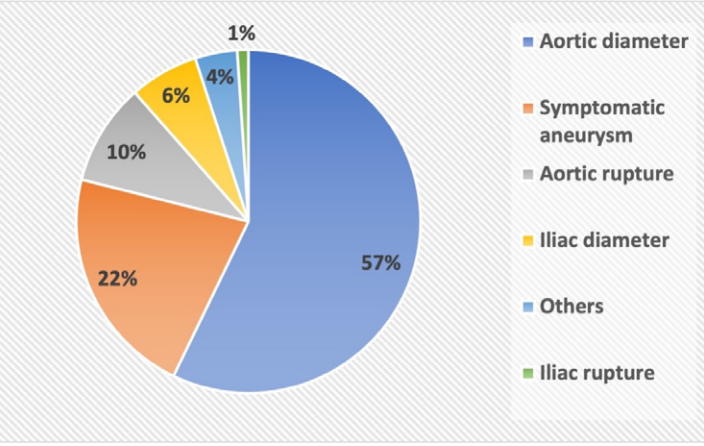
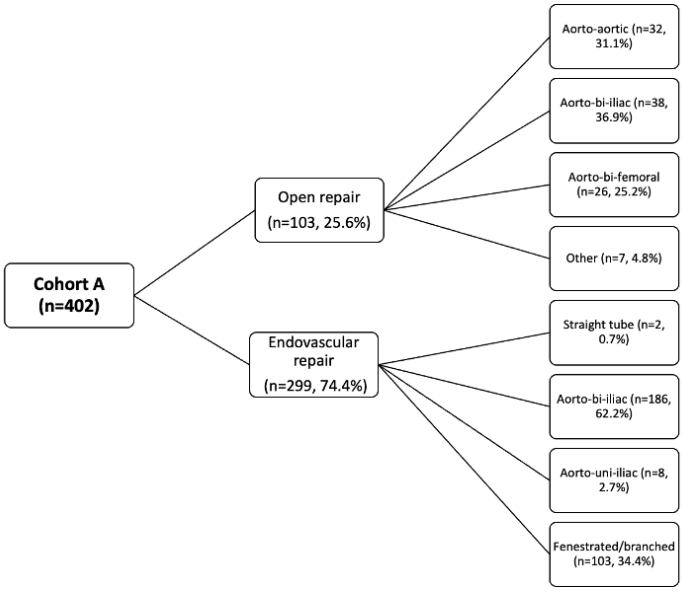


Figure 2. Type of graft used in AAA surgery in cohort A



AAA surgery was primarily performed electively (79.9% in cohort A vs. 80.9% in cohort B; p = 0.63). As illustrated in Figure 3, the annual proportion of elective procedures from 2020 to 2024 remained stable, with a slight increase in 2023 (85.88% in cohort A vs. 84.49% in cohort B; p = 0.93). Regarding endovascular procedures, 75.1% of all procedures were endovascular in cohort A, similar to cohort B (72.95%; p = 0.37; Figure 4). While the yearly proportion of endovascular procedures from 2020 to 2024 was constant in cohort B, we reported a progressive increase in cohort A until 2023, with significantly more endovascular procedures in 2023 (82.14% vs. 72.30%; p = 0.05). In 2023, when evaluating EVAR, this increase came at the expense of significantly more elective procedures (91.30% in cohort A vs. 83.23% in cohort B, p = 0.04). Regarding the type of anesthesia used during endovascular procedures, most procedures were performed under general anesthesia (94.4%). The remaining cases were performed under local anesthesia, with particular emphasis in emergent settings (0.4% of all elective cases vs. 42.4% of all emergent cases, p < 0.001).

Figure 3. Variation of elective procedures between 2020 and 2024

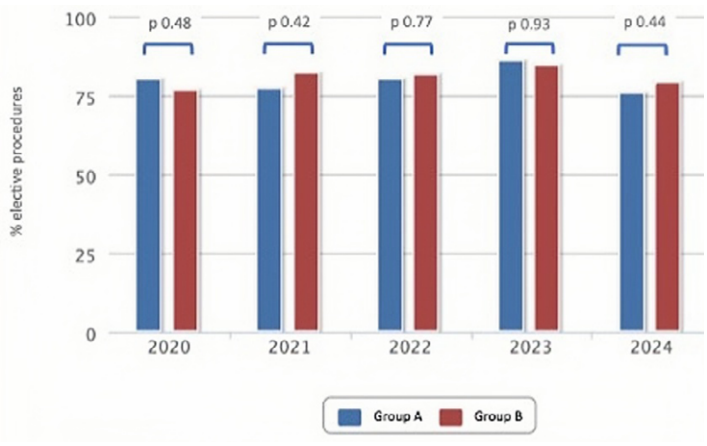
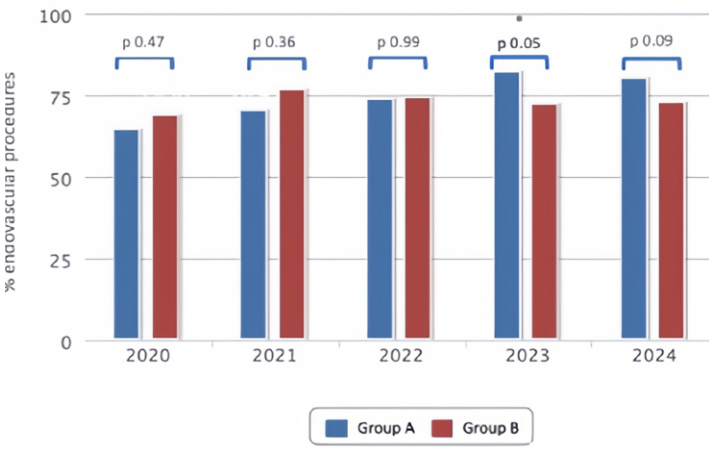


Figure 4. Variation of endovascular procedures between 2020 and 2024



Study outcomes

For the primary outcome, 30-day mortality in cohort A was 8.59%, significantly higher in urgent cases (31.25% vs 2.85%, p < 0.001). Table 2 reports the primary outcome by intervention type and setting. 30-day mortality was significantly higher in open repair and emergent cases, yet both cohorts had comparable outcomes. In cohort A, 30-day mortality was slightly lower in infrarenal aneurysms, though not statistically significant (7.8% vs. 9.7%, p = 0.5).

Table 2. 30-day mortality rates from 2019-2024

	Center/cohort A (n=402)	Overall/cohort B (n=2000)	p value
Elective open surgery	5.45%	5.00%	0.57
Elective EVAR	2.31%	2.02%	0.75
Urgent open surgery	40.91%	41.79%	0.71
Urgent EVAR	19.44%	18.65%	0.72

Regarding secondary outcomes, in cohort A, we reported a 30-day stroke rate of 1.52%, a 30-day myocardial infarction rate of 4.80%, a 30-day respiratory failure rate of 4.6%, and bowel ischemia in 4.04% of all patients. 4.98% of patients undergoing AAA surgery had KDIGO III acute kidney injury requiring continuous hemofiltration, particularly among those undergoing emergent surgery (19.51% vs. 1.25%, p < 0.001).

Secondary analysis on 30-day mortality (cohort A)

Table 3 summarizes a secondary analysis of 30-day mortality. In a multivariate analysis of cohort A, after retaining significant covariates, 30-day mortality was significantly correlated with age (per 10-unit increase, OR 1.068, p < 0.001), urgent setting (OR 1.24, p < 0.001), and preoperative creatinine (per 10-unit increase, OR 1.007, p = 0.006), while endovascular repair conferred a reduced mortality risk (OR 0.88, p < 0.001). Anatomical characteristics did not significantly affect survival (OR 0.79, p = 0.5).

Table 3. Predictive factors for 30-day mortality (group A secondary analysis)

Covariate	Univariate analysis	Multivariate analysis
Age*	1.037 (1.004-1.071)	**1.068 (1.036-1.101)**
Male sex	2.55 (0.34-19.42)	-
AAA diameter*	1.039 (1.021-1.057)	1.010 (0.994-1.027)
Infrarenal aneurysm	0.79 (0.39-1.59)	
Urgent setting	15.51 (6.87-35.00)	**1.24 (1.16-1.33)**
Endovascular surgery	0.17 (0.08-0.35)	**0.88 (0.82-0.94)**
Preoperative creatinine*	1.009 (1.004-1.015)	**1.007 (1.002-1.012)**
Diabetes	0.14 (0.02-1.01)	-
Cerebrovascular disease	0.88 (0.26-3.01)	-
Ischemic heart disease	0.82 (0.37-1.82)	-
Pulmonary disease	0.18 (0.04-0.76)	0.25 (0.05-1.22)

OR presented in absolute value and 95% CI; ***:** for continuous variables, OR is presented per-10 unit increase

DISCUSSION

Given that our caseload accounts for over 20% of all aortic surgeries performed in Portugal, it is of utmost importance to compare our results with the national standard of care and international registries. Only through harmonized prospectively collected registries can we monitor and improve outcomes and clinical practices.

First, we reported a shift toward more elective procedures across all study cohorts. In our data, over 80% of procedures were performed in an elective setting. These results are consistent with other international registries, such as Swedvasc and the VQI initiative.[6-10] This increase in elective procedures may reflect a rise in diagnostic exams and efforts to screen for AAA in certain societies, despite the absence of specific recommendations in Portugal on the latter. While our results mirror the national trend, some regional discrepancies have been previously reported. A 10-year analysis of abdominal aortic aneurysm repair in Portugal reported a greater increase in endovascular procedures at hospitals in Northern Portugal and Lisbon, despite an overall increase across mainland Portugal. These differences may be related to distinct referral logistics or hospital capacity to treat these cases.[11]

Concomitantly, our study reported 30-day mortality rates under 5% and more favorable outcomes for elective endovascular surgery. These results align with the main trials and most recent meta-analyses, which report 30-day rates of 2 to 3%. Nevertheless, 30-day mortality rates remain significantly higher in urgent cases than in elective cases, highlighting the need for timely diagnosis and intervention. In the national registry, both cohorts reported 30-day mortality rates of 19% and 40% for urgent EVAR and urgent open repair, respectively, with no statistically significant differences between cohorts A and B. In this context, a recent meta-analysis by Kontopodis and colleagues, which included an estimated 267 259 patients from 136 studies, reported a pooled perioperative mortality of 24.5% for EVAR and 37.8% for open repair.[15] Despite a discrepancy with the numbers reported in the SPACV registry, it must be noted that this meta-analysis included only infrarenal ruptured AAA. In our analysis, we did not exclude pararenal aneurysms, which are reportedly associated with greater complexity and significantly higher mortality rates in an emergent setting. When restricted to infrarenal aneurysms, a previous analysis of the first 1000 cases showed that the 30-day mortality in ruptured cases was 28.8% and 44.4% in the EVAR and OSR groups, respectively.[7] In a secondary analysis, age, preoperative creatinine, and ruptured setting were associated with higher mortality, which is in line with the literature.

Regarding differences between EVAR and open repair, one of the main issues is the progressive decline in exposure to open repair. There is a significant trend toward endovascular repair, as identified in a 2024 VQI evaluation that assessed all AAA surgeries from 2011 to 2021 and concluded that open repair had declined significantly and that complication rates were unexpectedly high.[10] Following most international societies and as reflected in our current clinical practice, with over 70% of procedures endovascular, the remaining cases for open repair are consequently anatomically more challenging and complex, which may explain the increased mortality rates.[16] In a review of 122 495 Medicare beneficiaries who underwent AAA surgery, Zettervall and colleagues concluded that higher surgeon volume is associated with lower 30-day mortality. This conclusion is also reflected in European guidelines.[5,17] However, this need for higher volume is not accompanied by an increase in surgical exposure among vascular trainees. As reported in a retrospective study by Smith and colleagues, open repair volume among training programs decreased by 38%, and a quarter of all residency programs offered fewer than 10 repairs per year.[18]

With the advent of less invasive therapies, particularly in elective settings, it is paramount to audit morbidity rates in aortic surgery. Perioperative complication rates in this study are broadly consistent with contemporary international experience in AAA repair. Stroke rates are typically low (<1% in standard EVAR, higher in complex repairs), making our rate of 1.52% acceptable.[5] Cardiac complications remain common, with reported myocardial infarction rates of 3–10%, in line with our finding of 4.80%.[19] Respiratory failure (5-14%) and bowel ischemia (1–5%) are also well described, placing our results within expected ranges.[19,20] Severe acute kidney injury following AAA repair remains a well-recognized complication, occurring in up to 30% of patients overall, with significantly higher rates in ruptured or emergent cases.[21] The need for renal replacement therapy is uncommon in elective settings but may exceed 10% in ruptured AAA, supporting our finding of a markedly increased rate of KDIGO stage III AKI in urgent surgery (19.51% vs. 1.25%). Overall, these findings are consistent with registry data, which continue to demonstrate increased morbidity in complex and emergent AAA repair despite improved techniques.

The main strength of this study is that it allows auditing of a single-center experience and comparison with a prospectively collected nationwide registry. With similar patients across the country, we were able to perform a benchmark analysis and identify potential areas for improvement, as part of a university center with the continuous need to improve vascular training and care. We shall highlight some limitations, namely a lack of mid- to long-term follow-up. This information is of utmost importance for comparing with existing trials and for benchmarking our practice against the latest evidence. Furthermore, there may be selection and information bias, since the database is based on voluntary registration, with entries from each participating center. Furthermore, since patient-level data were available only for the local cohort (cohort A), with few anatomical and procedural data available for cohort B, study outcomes must be interpreted with caution due to potential uncontrolled confounding.

CONCLUSIONS

Auditing national registries helps improve overall outcomes in aortic aneurysm repair. With a caseload of over 20% of all patients in Portugal, endovascular rates and 30-day mortality rates remain in line with current practices. Furthermore, real-world experience helps identify potential predictors of complications and mortality in our patients. This study highlights the need to review current practices, particularly vascular training, to improve exposure to open aortic repair and to establish high-volume centers for more complex interventions.

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