NATIONAL REGISTRY

Nationwide Analysis of Ruptured Abdominal Aortic Aneurysm in Portugal (2000–2015)

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WHAT THIS PAPER ADDS

The overall mortality of ruptured abdominal aortic aneurysm (rAAA) depends both on disease prevalence and mortality before and after hospital admission. In this article, the mortality related to rAAA was studied in Portugal based on national registries. Admission, repair, and mortality due to rAAA seem to have reached a peak and recently have been decreasing (2010–2015). At the same time, there was a gradual increased adoption of endovascular repair for ruptures. Mortality outside the hospital remains a matter of concern, warranting further planning of streamlined transfer networks and vascular surgical departments.

Objective: Ruptured abdominal aortic aneurysm (rAAA) is a lethal condition that requires acute repair to prevent death. This analysis aims to assess the nationwide trends in rAAA admission, repair and mortality in a country, Portugal, without national screening for AAA.
Methods: rAAA registered in the hospital administrative database of the National Health Service and all nationally registered deaths due to rAAA based on death certificate data were analysed. Three time periods (2000–2004, 2005–2009, and 2010–2015) were compared in patients $\geq$ 50 years old to assess the variations over time.
Results: A total of 2 275 patients $\geq$50 years old with rAAA were identified in the two databases from 2000 to 2015. The age standardised incidence of rAAA was 2.78 $\pm$ 0.24/100 000/year in 2000–2004, 3.17 $\pm$ 0.39/100 000/year in 2005–2009 and 3.21 $\pm$ 0.28/100 000/year in 2010–2015 ($p < .001$). When comparing the time periods 2000–2004 to 2005–2009, the age standardised rate of admission ($n = 1460$) increased from 1.57 $\pm$ 0.25/100 000/year to 2.24 $\pm$ 0.32/100 000/year ($p < .001$). The operative mortality rates decreased during this time period (from 55.3 $\pm$ 4.7% to 48.8 $\pm$ 4.7%, $p < .001$). In 2010–2015, the age standardised rate of admissions due to rAAA decreased (1.98 $\pm$ 0.22/100 000/year). Operative mortality remained stable (48.9 $\pm$ 6.2%). The rate of patient deaths outside the hospital decreased from the first to the second period (1.21 $\pm$ 0.10/100 000/year and 0.93 $\pm$ 0.29/100 000/year, respectively) but later increased (1.14 $\pm$ 0.22/100 000/year). This resulted in a higher overall rAAA related mortality in Portugal in the third period (2.20 $\pm$ 0.18/100 000/year, 2.21 $\pm$ 0.27/100 000/year and 2.26 $\pm$ 0.26/100 000/year in 2000–2004, 2005–2009, and 2010–2015, respectively, $p < .001$).
Conclusion: Overall, the incidence of rAAA in Portugal has been stable over the past 10 years. The rates of admission, repair, and death due to rAAA repair seem to have reached an inflection point and are now decreasing. Mortality outside the hospital remains a matter of concern, warranting further planning of streamlined transfer networks and vascular surgical departments.

Keywords: Abdominal aortic aneurysm, Epidemiology, Mortality, Incidence, Ruptured aneurysm
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INTRODUCTION

Despite recent technical advances, ruptured abdominal aortic aneurysm (rAAA) continues to account for significant mortality.[1] Rupture is often the presenting feature, and without emergency surgery mortality is close to 100%.

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Overall mortality after repair is estimated at 28.8% (27.9—29.8), 32.1% (31.0—33.2) for open surgical repair (OSR), and 17.9% (16.3—19.6) for endovascular repair (EVAR).[2] Being mostly asymptomatic before rupture, its detection relies on incidental findings on image studies performed for other reasons. Population screening for abdominal aortic aneurysm (AAA) has been shown to reduce rAAA mortality, and national screening programmes for AAA are currently implemented in Sweden, the United Kingdom, and the United States.[3—5] An association between screening programmes and decreased mortality from AAA has been demonstrated,[3,6—8] but its efficacy might depend on certain conditions such as the subpopulation screened, the healthcare and reimbursement systems.[9,10]

Epidemiological studies from United Kingdom, Finland, and Sweden suggest that a decrease in the prevalence of the disease itself may have contributed to the drop in AAA mortality rates even in the absence of screening.[11—13] This decrease in the prevalence of the disease has been credited mainly to the reduced smoking rate and change in cardiovascular risk factors as well as more widespread use of cardioprotective drugs.[13—16] The potential effect of EVAR on rAAA mortality remains under debate. While randomised controlled trials have not shown a short term survival benefit of EVAR for ruptures,[17] a possible advantage might come from the fact that older patients are more often treated by EVAR in the endovascular era resulting in a reduction in turn down rate,[12] with better short term survival than after OSR in registry studies.[18]

While most of the studies of AAA epidemiology are performed in the Northern European and US setting, data suggest that the AAA disease burden has significant geographical variations.[14] There are a paucity of data regarding the epidemiological transition in southern Europe, where factors affecting AAA prevalence such as smoking habits vary compared with northern Europe.[19]

At country level, a comprehensive national assessment of trends in AAA epidemiology may identify the need for further protocolled approaches and give insight into the expected healthcare costs associated with the treatment of this disease. The objective of this analysis was to assess the trends in rAAA rates of admission, repair, and death in Portugal.

MATERIALS AND METHODS

Study design

All rAAA admissions and interventions performed during the period 2000 to 2015 were identified retrospectively in a National Health Service (SNS) administrative database formerly designated as Diagnosis Related Groups (DRGs) database. This database was provided by the Portuguese Central Health System Administration (ACSS) and contains a registry of all hospitalisations (retrospective consecutive case entry) occurring in mainland Portugal public hospitals, where all rAAA repairs are performed. This is a mandatory registry for hospital reimbursement. All Portuguese residents have access to healthcare provided by the SNS, financed mainly through taxation. Private healthcare providers mainly fulfil a supplementary role to the SNS rather than providing a global alternative to it, providing mainly diagnostic, therapeutic, and dental services, as well as some ambulatory consultations, rehabilitation, and hospitalisation.[20] Over the period of the study, 14 centres provided rAAA repair, mainly located in the north and centre of the coastal western regions of Portugal.

Each registered hospital episode includes information about diagnoses and medical or surgical procedures, both coded using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). External audits are performed by the ACSS to verify the accuracy of the clinical coding performed at SNS hospitals. The episode presents no lack of conformity when it respects ICD-9-CM, Coding Clinic and National Consensus. The last one was in 2010 when a total of 4 510 episodes were audited in 44 hospital institutions. The results indicate that non-conformities among diagnoses, procedures, and other administrative and demographic variables in general did not affect the respective DRG groupings (non-conformities mean 13.7%, 26.5% maximum, 2.1% minimum).[21] The manuscript follows the RECORD statement,[22] extended from the STROBE statement.[23]

Data collection

All admissions considered to have a primary diagnosis with specific ICD-9-CM code for rAAA (Table S1) were included in this analysis. The primary diagnosis of an episode represents the main condition investigated or treated during that hospital stay. Aortic aneurysms at unspecified site were included, in line with other studies,[13,24] to increase the chance that all abdominal lesions were captured in the analysis. Thoraco-abdominal aneurysms were excluded. The repair rate was calculated based on the episodes of care with the above mentioned ICD-9-CM disease codes plus the ICD-9-CM procedure codes suitable for AAA repair (Table S1). Owing to the lack of a specific ICD9-CM code for EVAR before 2000, the first period of the analysis was set to null to avoid the early years of EVAR code use.

Admissions with a primary diagnosis of rAAA that lacked an ICD-9-CM procedure code suitable for AAA repair that were discharged alive were confirmed as transfers between hospitals. Admissions with a primary diagnosis of rAAA that lacked an ICD-9-CM procedure that were discharged as deceased were considered as patients that died on arrival to the hospital prior to attempted repair, or that were turned down for surgery.

The number of admissions with repair in which the patient died divided by the number of all admissions with repair was defined as operative mortality due to rAAA. All hospital deaths for patients with a rAAA diagnosis were considered as rAAA related deaths, irrespective of the direct cause of death. The hospital mortality, however, is an underestimation of the national rAAA related mortality as it

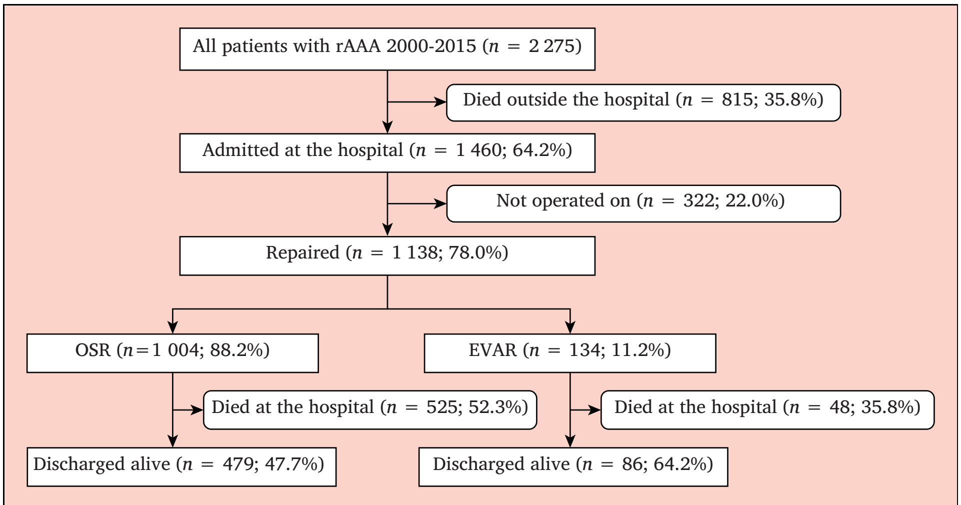

Figure 1. Outcomes of absolute numbers of episodes due to ruptured abdominal aortic aneurysm (rAAA) in Portugal, 2000—2015. EVAR = endovascular aneurysm repair; OSR = open surgical repair.

only includes patients presenting alive to a hospital. To overcome this limitation, death certificates with rAAA specific mortality were provided by the National Institute of Statistics (INE) from 2000 to 2015. The INE database used the ICD-9-CM classification from 2000 to 2001 and the Tenth Revision (ICD-10) thereafter. Both databases present episode related data retrievable through ICD codes. For INE data, the episode is death and includes deaths outside the hospital as well as those certified at the hospitals. In the SNS administrative database, each episode refers to a hospitalisation. The resident population in each year under analysis was also provided by the INE from 2000 to 2015. Resident population per year was used to calculate the rate of rAAA admission, repair and mortality. In both databases, individuals <50 years of age were excluded. Gender subgroups were provided only for patients presenting to the hospital.

Statistical analysis

Data were calculated overall and for three periods (2000—2004, 2005—2009 and 2010—2015) to assess variations over time. Besides the frequency of episodes/cases per year, gender and age were available in the SNS database, and age but not gender was available in INE database. There were no missing cases. Subgroup analysis was performed to investigate trend differences based on sex and age (<75 or ≥ 75 years old) as previously performed.[13]

To account for changes in the age structure of the population over time, age direct standardisation was performed (using the World Health Organisation world standard population[25]). All rates of admission and death were presented as age standardised data. Age standardised rate of admission refers to all rAAA that arrived at the hospital for one year, including those that died without an attempt to repair plus those with a repair attempt, divided by the nationwide population during that year. Age standardised incidence refers to all known cases of rAAA for one year, that is all rAAA that arrived at the hospital (as defined above) plus all rAAA cases that died without reaching hospital, divided by the nationwide population during that year.

Continuous variables are presented as mean ± standard deviation, after histogram inspection. Proportions were compared using the chi square test. Changes in proportions over time were assessed using the chi square test for trend. Normally distributed data were compared using one way ANOVA. Bonferroni correction was used to adjust for multiple testing. Furthermore, to adjust for subgroup analysis $p < .01$ was considered significant. All statistical analysis was performed using SPSS for Mac version 24 (SPSS, IBM Corp., Armonk, NY).

RESULTS

A total of 2 275 patients ≥50 years old with rAAA were identified in the two databases from 2000 to 2015 (Fig. 1), after removal of duplicates.

Incidence of rAAA

The age standardised incidence of rAAA increased between 2000 — 2004 and 2005—2009, and remained stable after that in 2010—2015 ($p < .001$) (Table 1 and Fig. 2). In the subgroup of patients <75 years old, the age standardised incidence declined in the third period ($p < .001$) while it increased in patients ≥ 75 years old ($p < .001$). A total of 403 (18%) cases were <65 years old, i.e., below the recommended age for AAA screening.

rAAA presenting to the hospital

A total of 1460 hospital admissions due to rAAA were identified in patients ≥50 years old (Table 1). The age standardised admission rate per 100 000 inhabitants increased between 2000—2004 and 2005—2009 and then decreased in 2010—2015 ($p < .001$) (Fig. 2).

Table 1. Patient characteristics and rates of incidence, admission and repair of ruptured abdominal aortic aneurysm (rAAA) across three time periods (2000–2004, 2005–2009 and 2010–2015) in Portugal

	2000–2015	2000–2004	2005–2009	2010–2015	*p* value
All cases with rAAA	2275	582	723	970	–
Cases/year	142	116	145	162	<.001
Proportions of ≥75 years – %	50.2 ± 4.1	48.2 ± 4.3	48.2 ± 1.6	53.5 ± 3.7	<.001
Standardised rate per 100000/year					
All cases	3.07 ± 0.35	2.78 ± 0.24	3.17 ± 0.39	3.21 ± 0.28	<.001
<75 years	2.18 ± 0.29	1.96 ± 0.23	2.34 ± 0.34	2.23 ± 0.20	<.001
≥75 years	8.27 ± 0.83	7.81 ± 0.84	8.28 ± 0.80	8.64 ± 0.79	<.001
Cases with rAAA presenting to hospital	1460	335	508	617	–
Cases/year	91	67	102	103	<.001
Proportions – %					
≥75 years	50.4 ± 6.2	49.7 ± 6.9	47.3 ± 4.2	53.6 ± 6.4	<.001
Men	87.8 ± 3.6	88.2 ± 4.1	88.4 ± 3.5	87.0 ± 3.9	<.001
Not operated on	22.0 ± 3.6	20.9 ± 4.4	21.5 ± 3.4	23.0 ± 4.2	<.001
OSR	69.8 ± 9.3	79.0 ± 4.4	73.1 ± 5.3	59.4 ± 3.9	<.001
EVAR	13.0 ± 6.9	–	7.6 ± 4.9	17.6 ± 4.7	<.001
Proportion of not operated on – %					
In patients <75 years	15.7 ± 5.6	18.0 ± 2.6	18.8 ± 6.6	11.4 ± 4.0	<.001
In patients ≥75 years	27.5 ± 7.6	23.4 ± 8.8	24.9 ± 2.7	33.2 ± 6.5	<.001
In men	19.8 ± 4.0	19.5 ± 3.0	19.5 ± 5.4	20.4 ± 4.0	.004
In women	35.4 ± 17.4	29.1 ± 23.8	37.4 ± 17.2	39.2 ± 12.4	.007
Proportion undergoing repair – %					
In patients <75 years	84.3 ± 5.6	82.0 ± 2.6	81.2 ± 6.6	88.6 ± 4.0	<.001
In patients ≥75 years	72.5 ± 7.6	76.6 ± 9.3	75.1 ± 2.7	66.8 ± 6.5	<.001
In men	80.2 ± 4.0	80.5 ± 3.0	80.5 ± 5.4	79.6 ± 4.0	.004
In women	64.6 ± 17.4	70.9 ± 23.8	62.6 ± 17.2	60.8 ± 12.4	.007

Data are presented as *n*, or mean ± standard deviation. Proportions (%) are presented as the mean and standard deviation of all annual percentages for each time period. *p* values were calculated resorting to ANOVA after adjustment for multiple comparison. OSR = open surgery repair; EVAR = endovascular repair.

Fifty per cent of admitted patients (735) were ≥75 years, while 426 (29%) were ≥80 years. The proportion of patients ≥75 years old arriving to hospital increased significantly in the third period ($p < .001$) (Table 1).

rAAA undergoing repair

From all the admissions, the age standardised rate of non-intervention also followed a rise–fall pattern (Fig. 2). Overall, 22 ± 4% of the admitted patients did not undergo repair (Table 1). The proportion was 35.4 ± 17.4% in women, and 19.8 ± 4.0% in men ($p < .001$). The proportion was also higher in patients ≥75 years *vs.* < 75 years old (27.5 ± 7.6% *vs*. 15.7 ± 5.6%, $p < .001$). Over time, the proportion of patients not undergoing repair increased ($p < .001$).

rAAA mortality

Overall, 75.2 ± 4.7% patients having a rAAA died before reaching the hospital or during the hospitalisation (Table 2). The rAAA age standardised mortality was stable between the first and second time period, and increased slightly in the third period (Table 2). In a subgroup analysis, the increase in age standardised mortality in the third period occurred among ≥75 year olds (Table 2). This increase was primarily related to an increase in rAAA deaths outside the hospital (Table 2 and Fig. S1). The age standardised mortality for patients admitted to hospital (repaired or not) however decreased in the final time period (Table 2).

The operative mortality after rAAA repair decreased from 55 ± 5% in 2000–2004 to 49 ± 5% in 2005–2010 ($p < .001$) and then stabilised in 2010–2015 at 49 ± 6% (Fig. S1). This later stabilisation phase corresponded to an increase in operative mortality due to OSR (55 ± 5% to 48 ± 5% to 54 ± 6%, $p < .001$) compensated for by a decrease in operative mortality after EVAR (from 75 ± 24% in the second to 29 ± 11% in the third period, $p < .001$) (Fig. S2).

In the subgroup of males, the operative mortality dropped from 55 ± 4% in 2000–2004 to 47 ± 7% in 2005–2009 ($p < .001$) and remained stable in 2010–2015 (48 ± 6%, $p = .034$). Operative mortality in female patients did not vary significantly during the time period but global figures in females were significantly higher than in males (50 ± 6% *vs*. 53 ± 20%, $p < .001$) (Fig. 3).

The operative mortality rate in ages <75 years old decreased from 47 ± 6% to 38 ± 6% ($p < .001$) and then remained constant (38 ± 8%). In the age band ≥75 years old, the operative mortality rates were 65 ± 6%, 61 ± 10%, and 61 ± 8% ($p < .001$). Mortality in the elderly cohort was thus higher than in patients <75 years old ($p < .001$) (Fig. S3).

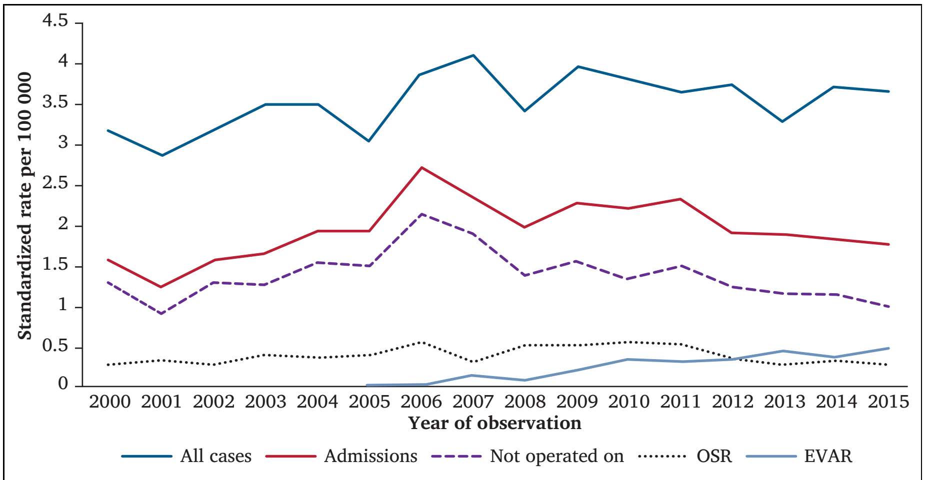

Figure 2. Age standardised rate of admissions and repair due to ruptured abdominal aortic aneurysm per 100 000 inhabitants ≥50 years old per year (2000–2015) in Portugal. The *p* value (ANOVA) for the comparison of the periods 2000–2004, 2005–2009 and 2010–2015 was <.001 for all cases, admissions, not operated on, OSR, and EVAR. EVAR = endovascular aneurysm repair; OSR = open surgical repair.

DISCUSSION

In this study, a nationwide evaluation of the incidence, admission, repair, and mortality due to rAAA over 16 years was performed. The study found that, overall, the incidence of rAAA in Portugal increased between 2000–2004 and 2005–2009, and stabilised thereafter. The decreased incidence of disease verified in Western countries[11–13,26] is offset by an increased incidence in the older population. Overall, the number of rAAA cases per year has increased. Despite an improved peri-operative mortality, and an increased repair rate among younger patients presenting with rAAA to hospital, the overall death rate per 100 000 inhabitants has increased over recent years. This is because an increasing number of rAAA deaths are registered among patients not presenting to hospital.

A direct comparison of the rates of rAAA admission among other reports is made more difficult by studies reporting non-standardised rates, representing different subgroups of age and gender. Nevertheless, the rates reported in this study lag behind those described in other reports as previously noted.[27] This might be because a great number of patients do not reach the hospital, due to a lower prevalence of the disease in Portugal or related to external validity of the databases. A population screening initiative in men ≥65 years old with an eligible population of about 900 males that took place in Portugal[28] yielded a prevalence of 2.1%. In countries where national screening is formally implemented, prevalence rates were as low as 1.2% in England[29] and 1.7% in Sweeden.[10] An increasing number of elective operations, resulting from increased use of imaging resulting in the incidental detection of AAA,[3,6,7] may partly explain the decrease in rAAA incidence. Nevertheless, countries with higher rates of elective AAA treatment may not have fewer ruptured AAA repairs.[27] In a recent systematic review, the country with the lowest number of elective treatments (Hungary) also has the lowest rate of emergency repairs (0.5 per 100 000) and the country with the highest rate of intact repairs (Germany) was also one of the countries with a higher number of ruptured AAAs (2.7 per 100 000). Further reduction of rAAA mortality might require the identification and surgical treatment of more asymptomatic patients before AAA rupture through screening, although formal studies in the Portuguese population are needed in order to address its benefit.

One might hypothesise that the widespread dissemination of endovascular technology in older patients in the emergency setting might have contributed to improved survival among patients undergoing repair,[30] nevertheless further evidence is needed to address that. In a meta-analysis that included 24 adjusted observational studies and four randomised controlled trials (RCTs) enrolling a total of 56 826 patients with rAAA,[31] pooled analysis demonstrated a statistically significant 49% reduction in peri-operative all cause mortality with EVAR relative to OSR in observational studies and no statistically significant difference between EVAR and OSR in RCTs. As in other observational studies, the use of EVAR was associated with lower operative mortality both in male and female patients in the current cohort. Interestingly, during the introduction of EVAR for rAAA in Portugal, the mortality of this procedure was excessively high. It is possible that this corresponds to wider use of the new minimally invasive technique mainly in patients that were unable to tolerate OSR due to comorbidities, or due to the learning curve of the new technology. A significant decrease both in the in hospital mortality and length of stay with experience accumulated at the hospital level was observed for EVAR.[32] Over time, however, operative mortality of EVAR for rAAA has stabilised at a low level, while the operative mortality after OSR increased in the third period. Data from the American College of Surgeons' National Quality

Table 2. Age standardised mortality rates referring to nationwide deaths from ruptured abdominal aortic aneurysm (rAAA) across three time periods (2000–2004, 2005–2009, and 2010–2015) in Portugal

	2000–2015	2000–2004	2005–2009	2010–2015	*p* value
All deaths from rAAA	1710	463	519	728	–
Deaths/year	107	93	104	121	<.001
Proportions of ≥75 years – %	55.1 ± 4.9	51.0 ± 3.8	53.6 ± 1.7	59.7 ± 3.8	<.001
Mortality among all incident cases – %	75.2 ± 4.7	79.6 ± 3.7	71.7 ± 3.1	74.9 ± 3.9	<.001
Standardized rate per 100000/year					
All deaths	2.22 ± 0.23	2.20 ± 0.18	2.21 ± 0.27	2.26 ± 0.26	<.001
<75 years	1.48 ± 0.19	1.48 ± 0.15	1.49 ± 0.19	1.47 ± 0.26	.55
≥75 years	6.79 ± 0.72	6.58 ± 0.80	6.61 ± 0.91	7.12 ± 0.42	<.001
Deaths from rAAA outside the hospital	815	247	215	353	–
Deaths/year	51 (47.7)	49 (53.3)	43 (41.4)	59 (48.5)	<.001
Proportions of ≥75 year – %	50.8 ± 5.8	46.7 ± 5.2	51.0 ± 7.1	54.1 ± 3.1	<.001
Standardized rate per 100000/year					
Deaths outside hospital	1.10 ± 0.23	1.21 ± 0.10	0.93 ± 0.27	1.14 ± 0.22	<.001
<75 years	0.78 ± 0.19	0.88 ± 0.14	0.68 ± 0.23	0.82 ± 0.19	<.001
≥75 years	2.95 ± 0.58	3.21 ± 0.19	2.52 ± 0.75	3.10 ± 0.51	<.001
Deaths from rAAA at the hospital	895	216	304	375	–
Deaths/year	56	43	61	62	<.001
Proportions–%					
≥75 years	59.6 ± 7.1	56.2 ± 5.6	56.0 ± 3.2	65.4 ± 7.4	<.001
Men	85.6 ± 6.4	87.5 ± 7.0	84.9 ± 8.0	84.5 ± 5.2	.003
In-hospital mortality among all cases presenting to hospital – %	61.5 ± 5.6	64.5 ± 5.6	59.7 ± 5.2	60.6 ± 6.0	<.001
Standardized rate per 100000/year					
Deaths at the hospital	1.13 ± 0.23	0.99 ± 0.15	1.28 ± 0.24	1.11 ± 0.24	<.001
<75 years	0.68 ± 0.19	0.60 ± 0.09	0.82 ± 0.18	0.64 ± 0.23	<.001
≥75 years	3.84 ± 0.66	3.38 ± 0.70	4.09 ± 0.65	4.02 ± 0.50	<.001
Men	2.36 ± 0.52	2.08 ± 0.20	2.64 ± 0.67	2.35 ± 0.50	<.001
Women	0.22 ± 0.11	0.18 ± 0.14	0.25 ± 0.10	0.23 ± 0.09	.018
Deaths after rAAA repair	573	146	195	232	–
Deaths/year	36	29	39	39	<.001
Proportions – %					
≥75 years	57.1 ± 7.0	56.3 ± 4.2	57.3 ± 9.1	58.1 ± 9.1	.18
Men	57.3 ± 5.6	60.9 ± 5.7	56.3 ± 6.3	55.2 ± 4.3	<.001
EVAR	7.3 ± 4.1	–	5.6 ± 3.5	8.7 ± 4.4	.010
Operative mortality – %					
In all repaired cases	50.9 ± 5.8	55.3 ± 4.7	48.8 ± 4.7	48.9 ± 6.2	<.001
In patients <75 years	41.0 ± 7.5	46.8 ± 6.4	38.4 ± 6.1	38.5 ± 8.2	<.001
In patients ≥75 years	62.3 ± 7.4	65.1 ± 5.7	61.1 ± 9.7	61.0 ± 7.7	<.001
In men	50.2 ± 6.2	55.1 ± 3.6	47.4 ± 6.8	48.4 ± 5.7	<.001
In women	53.4 ± 20.3	53.2 ± 22.7	52.3 ± 27.1	54.3 ± 15.5	.91
After EVAR	50.0 ± 29.6	–	75.2 ± 24.0	29.0 ± 11.1	<.001
After OSR	52.6 ± 6.0	55.3 ± 4.7	47.8 ± 5.4	54.5 ± 5.9	<.001

Data are presented as *n*, or mean ± standard deviation. Proportions (%) are presented as the mean and standard deviation of all annual percentages for each time period. *P* values were calculated resorting to ANOVA after adjustment for multiple comparison. OSR = open surgery repair; EVAR = endovascular repair.

Improvement Program database showed that for all rAAAs with hypotension, OSR had increased mortality compared with EVAR ($p < .0004$).[33] It is possible that the higher mortality with OSR was due to selection bias where patients with hypotension or more complex aneurysms are more likely to undergo OSR. Despite the widespread use of endovascular technology in elective cases, EVAR was used only in 11% of all emergency cases, or one EVAR to 7.5 OSR cases. These odds are clearly below those found in elective repair over the same period (one EVAR to 1.7 OSR in Portugal, data from the SNS administrative database, not published). This suggests that although surgeons became increasingly comfortable using EVAR in a controlled setting, this does not translate directly into emergency use.[33] The offer of EVAR in the emergency setting comes with a greater complexity that involves not only the surgeon's expertise but also the availability of a wide range of endograft sizes and ancillary material on the shelf, a suitable operation room, and an autonomous team to plan and perform the case, all during 24 h a day and seven days a week. Efforts to accommodate the increase of EVAR for rAAA in Portugal, including vascular training focused on EVAR on hypotensive patients and the use of resuscitative endovascular balloon occlusion of the aorta may contribute to a further gain in rAAA mortality in the future.

The overall rAAA mortality burden is significantly affected by the turndown rate for surgery among patients who present to hospital with a rAAA diagnosis. The turndown rate of rAAA has previously been estimated at 40% (33—47%) in a meta-analysis of 24 retrospective cohort studies.[26] In the present report, the average percentage from 2000—2015 was 22%. Cases admitted but not operated on showed a drop after adjusting for age variation of the population through standardisation. This suggests that gains obtained in mortality do not seem to be due to selection bias of better cases for repair.

Finally, a full understanding of the epidemiology of rAAA requires a look into patients that die without reaching the hospital, estimated in 32% (27—37%) in the same meta-analysis.[26] In the present study, on average 36% of patients died outside the hospital from 2000 to 2015. This percentage rose in the third period after a decrease from the first to the second periods. The rate of patients that die outside the hospital can be related to several factors. First, these ratios may reflect the transportation time to vascular departments that can deal with aortic rupture. Vascular departments that receive rAAA patients are located in the north and centre of the coastal western regions of Portugal. Thus, populations from south and eastern regions of the country do not have access to a nearby specialised vascular surgery department. To what extent the existence of a wider distribution of centres that offer rAAA repair *vs.* the benefits of centralisation in high volume centres is yet to be assessed in Portugal.[34]

It is important to underline, however, that the registration of rAAA as cause of death among patients not reaching hospital may be affected by factors other than disease prevalence. In patients that die without reaching hospital the cause of death is diagnosed based on clinical aspects and previous medical history, as well as autopsy if deemed necessary. Completeness of statistics on cause of death in Portugal, that is number of deaths for which cause of death is registered to the civil registration system, is fairly good compared with the member states of the World Health Organisation. Portugal was among the 42% of the WHO member states that provided data completeness of 70%—100%.[35]

Despite providing data from two different and complementary databases, this study has some limitations.

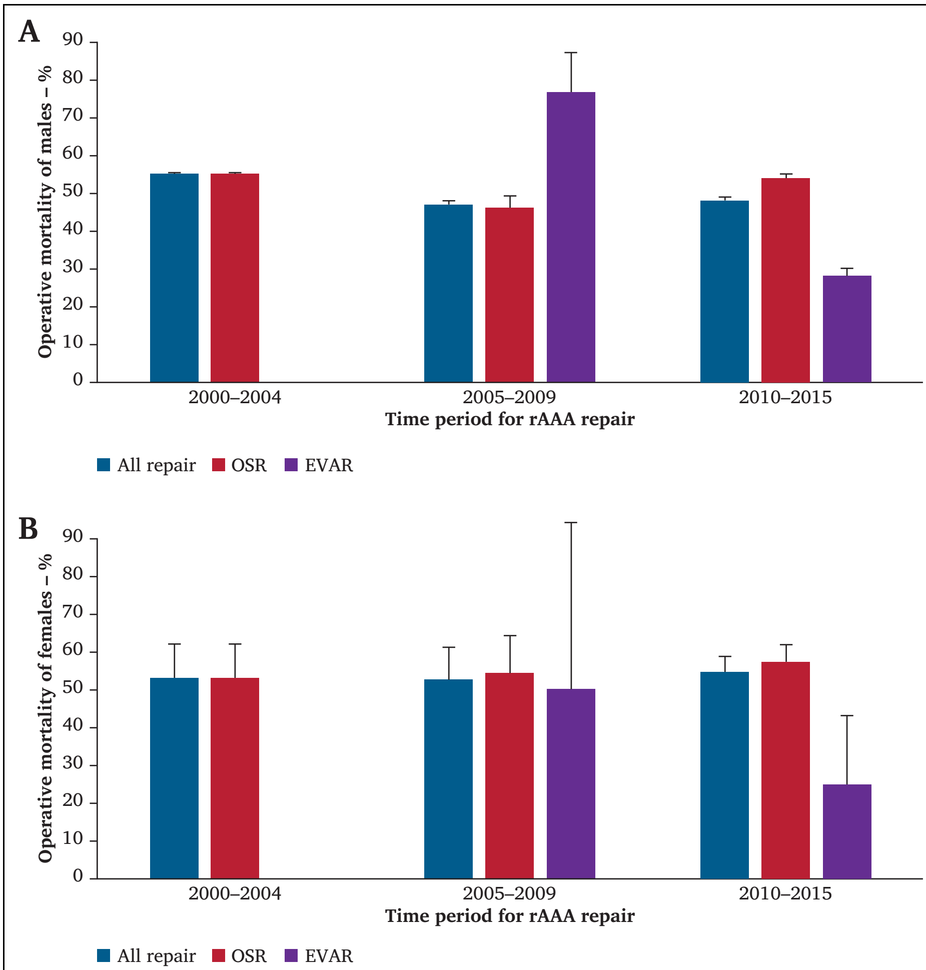

Figure 3. Percentage of operative deaths among different types of ruptured abdominal aortic aneurysm (rAAA) repair per gender male (A) and female (B) among three time periods (2000—2004, 2005—2009 and 2010—2015) in Portugal. EVAR = endovascular aneurysm repair; OSR = open surgical repair.

Contrary to the death certificate database from INE that includes prospective registration, the SNS administrative database contains a retrospective registration of all hospitalisations occurring in public hospitals in mainland Portugal. It is fed by independently trained physicians, representing a snapshot of the real world situation. Coding accuracy is guaranteed by proper training of the staff and external audits.[21] Because of the previously mentioned features of the Portuguese health system,[20] the number of rAAAs referred and treated in the private sector is nil or, at least, negligible in Portugal and not a realistic source of relevant selection bias. A second limitation of this study is the limited follow up as only data associated with a specific hospital episode is available in the SNS database. Since an emergency situation (i.e., rAAA) is the focus of this paper, it is expected that most rAAA related casualties occur at the time of the first hospitalisation. However, later deaths may occur, and these are not captured in this analysis. Third, ICD data was used rather than patient level data which precluded adjustment of the results for co-morbidities, the type of anaesthesia used or the aetiology of the AAA (degenerative *vs.* mycotic). Fourth, admission, repair, and mortality due to rAAA seem to have reached a peak and have been decreasing recently. The authors are not aware of events happening globally or in Portugal that could have affected treatment decisions differentially over these time periods. Furthermore, these shifts follow what has been observed in the epidemiological evolution of the disease in other countries. However, the pattern of a significant increase and then decrease (or vice versa) might rather be random fluctuation in the data that are hard to discern without a longer time period of data collection. Further studies with a longer time period of data collection might confirm these results. Fifth, like in other countries, autopsy rates are declining, from 6.7 $\pm$ 0.3% of all deaths in 2000–2005 to 6.4 $\pm$ 0.2% in 2005–2009 and to 5.5 $\pm$ 0.8% in 2010–2015. The proportion of patients dying outside a hospital setting is prone to error owing to misdiagnosis of the cause of death if no autopsy is performed and no previous diagnosis of AAA exists. Likewise, patients with known AAA might be wrongly diagnosed as rAAA death.

CONCLUSION

Nationwide evaluation of rAAA from 2000 to 2015 showed that overall, the incidence of rAAA in Portugal is stable over the past 10 years. Whilst the incidence of rAAA admissions, as well as mortality among patients presenting to hospital have decreased in the recent years, the overall mortality related to rAAA in Portugal increased. This was due to an increasing incidence of rAAA related deaths registered among individuals who died outside hospitals, showing that mortality outside the hospital remains a matter of concern.

CONFLICT OF INTEREST

None.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2020.02.024.

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