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In-hospital Operative Mortality of Ruptured Abdominal Aortic Aneurysm: A Population-based Analysis of 5593 Patients in The Netherlands Over a 10-year Period

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***Objective**. To determine the operative mortality of ruptured abdominal aortic aneurysm (RAAA) in The Netherlands.*
***Design**. Retrospective population-based study of nation-wide in-hospital mortality of RAAA repair.*
***Methods**. Data were obtained from a national registry for medical diagnosis and procedures. In-hospital mortality of RAAA repair, defined as death during hospital admission irrespective of the cause of death, was determined in the period 1991–2000. Variables of potential influence on in-hospital mortality, including age, gender, date of surgery and hospital type (0–399 beds, ≥400 beds or university hospitals) were studied in a multivariate analysis.*
***Results**. The overall in-hospital mortality of RAAA repair in 5593 patients in the 10-year period was 41% (95% confidence interval: 40–42%). In the multivariate analysis, age and hospital type were the most important independent predictors for in-hospital mortality. Gender, year and season of surgery could not be identified as significant risk factors.*
***Conclusions**. Over a recent decade, in-hospital mortality of RAAA repair remained unchanged at 41%. Age and hospital class were the most important independent risk factors.*

Keywords: Aneurysm; Aorta; Ruptured; Mortality; Operative.

Introduction

Although the mortality of elective surgical treatment for abdominal aortic aneurysm (AAA) is low and has decreased since the introduction of endovascular treatment,[1] the prognosis of ruptured AAA (RAAA) repair remains poor. With the exception of Bown *et al.*, who reported a gradual reduction of mortality following RAAA repair in a recent meta-analysis,[2] all studies describe an unchanging mortality of around 50%.[3–8]

Several factors have been identified as predictors for mortality of RAAA, including the physical condition of the patient at the time of admission,[7,9] gender of the patient,[5,10] type of hospital[5,11] and the experience of the surgeon.[4,7,8,12] Furthermore, a seasonal influence on the incidence of rupture has been suggested.[13–15]

The aim of this study was to quantify, in a population-based analysis, in-hospital mortality of ruptured infrarenal AAA repair in The Netherlands over a 10-year period.

Materials and Methods

All patients who underwent operative treatment for a ruptured infrarenal AAA in The Netherlands from 1991 through the year 2000 were included in the study. Patients who died before reaching the operating table were excluded.

Data were obtained from Prismant, The Institute for Health Care Management (Utrecht, The Netherlands), a national registry for medical diagnosis and procedures to which all hospitals in The Netherlands report.

Using the ICD 9 diagnosis code 441.3 (infrarenal abdominal aortic aneurysm with specific mention of rupture) in combination with the operation codes for repair of infrarenal abdominal aortic aneurysm, all patients operated for RAAA were identified. Patients with a symptomatic, but intact (or non-ruptured) AAA were not included.

Anonymous individual information including age,

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gender, date of surgery and hospital size (0–399 beds, ≥400 beds or university hospitals) was obtained. The end-point was operative in-hospital mortality, defined as death during hospital admission irrespective of the cause of death. Using multiple linear regression analysis, the influence of year and season of treatment, type of hospital, patient age and gender on in-hospital mortality were investigated. Statistical analysis was performed using SPSS 12.1 for Windows.

Results

From 1991 through 2000, 5593 patients underwent operative treatment for a ruptured infrarenal AAA in The Netherlands. There were 4930 men (88.1%) and 663 women (11.9%). The number of procedures performed in each year of the study period did not change significantly (Fig. 1). The overall in-hospital mortality was 41% (95% confidence interval (CI): 40–42%) (Table 1) varying from 37% in 1992 (95% CI: 33–41%) to 47% in 1994 (95% CI: 43–51%) (Fig. 2). The year of surgery did not have a statistically significant impact on mortality ($p=0.32$) (Table 2).

Gender distribution and mean age did not change over the years. The overall in-hospital mortality was 40% (95% CI: 39–41) in men and 49% (95% CI: 46–53) in women. The mortality in women was higher, compared with men, in all age categories. However, the difference in mortality was only statistically significant in the age category 60–69 years of age ($p=0.012$). The differences in mortality between men and women over time were only statistically significant in 1994: 45% (95% CI: 41–50) in men and 59% (95% CI: 47–71) in women ($p=0.038$), 1998: 38% (95% CI: 34–42) in men and 52% (95% CI: 41–63) in women ($p=0.020$) and 2000: 37% (95% CI: 33–42) in men and 52% (95% CI: 40–65) in women ($p=0.018$). Overall, gender was not a significant influence on in-hospital mortality in multivariate linear regression analysis ($p=0.24$) (Table 2).

The strongest predictor of in-hospital mortality was age ($p<0.0005$) (Table 2). The mean age at the time of surgery in women was 75.5 years (median age 77 years; range 45–92 years). For men, the mean age at surgery was 71.2 years (median age 72 years; range 24–95 years). The number of procedures in the different age groups for both sexes is presented in Fig. 3: 45% of the procedures were performed on patients in the age group 70–79 years, 31% of the procedures on patients between 60 and 69 years.

Mortality for the different hospital sizes, over the studied decade, was 36% (95% CI: 33–39) for the category 0–399 beds; 42% (95% CI: 40–44) for ≥400 beds and 44% (95% CI: 41–48) for university hospitals (Fig. 4(a)). Hospital type was a significant predictor of in-hospital mortality in multivariate linear regression analysis ($p<0.0005$). The number of procedures performed in the different hospital categories is represented in Fig. 4(b). In comparison with the largest group (≥400 beds), the mortality was significantly lower in the hospitals with 0–399 beds ('Hospital 1', Table 2) ($p<0.0005$); the mortality in the university hospitals ('Hospital 2', Table 2) was not different from mortality in the largest hospitals ($p=0.41$).

In-hospital mortality appeared to increase in the summer in comparison to the other seasons (Table 1). However, in multivariate analysis the season in which surgery took place did not have a significant influence on in-hospital mortality ($p=0.27$) (Table 2).

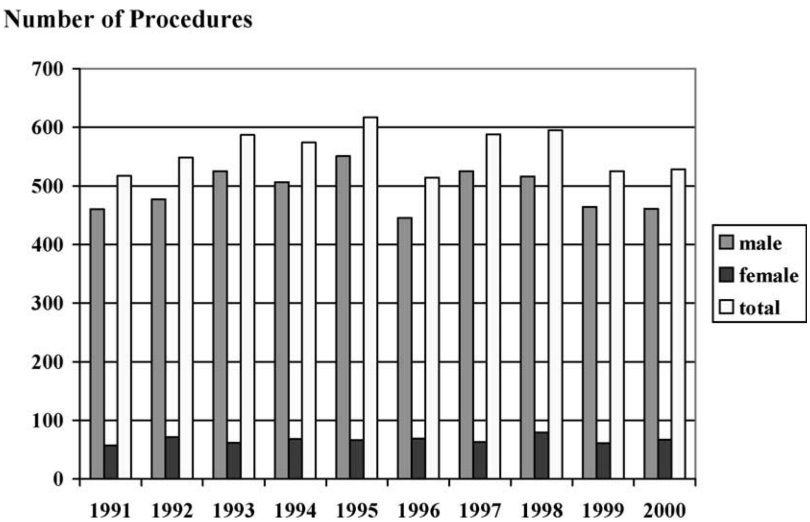

Fig. 1. Number of ruptured infrarenal abdominal aortic aneurysm repairs performed in The Netherlands in the last decade.

Table 1. Seasonal distribution of ruptured infrarenal aortic aneurysm repair in The Netherlands between 1991 and 2000 (univariate analysis)

Period	No. of patients	Mortality (95% CI)
Overall	5593	41% (40–42%)
Spring	1325	40% (38–43%)
Summer	1315	44% (41–46%)
Fall	1461	41% (38–43%)
Winter	1492	40% (38–43%)

Discussion

In this nationwide study no temporal change of in-hospital operative mortality following RAAA repair was found over the decade 1991–2000. Following the first successful elective repair in 1952,[16] mortality of elective aneurysm surgery gradually has declined over the years. This has been attributed to improved operative techniques as well as post-operative care. Bown *et al.* indicated a gradual reduction of mortality following RAAA repair over a 50-year period.[2] We could not confirm this finding for mortality in the previous decade.

Data were obtained from Prismant, which is a national registry for medical diagnosis and procedures to which all academic and general hospitals in The Netherlands report. Obviously, the study limitations are strongly related to the use of this database. Only a limited number of possible variables and trends can be analysed from a registry, whereas operative mortality for RAAA has been demonstrated to correlate with several cardiovascular factors,[9] the experience of the surgeon and intra-operative management during emergency operations.[6,9,11]

Table 2. Multivariate analysis of 5593 patients with ruptured infrarenal aortic abdominal aneurysm repair over the decade 1991–2000

Model	Risk increase		*F*	*p*-value
	B	Standard error		
Age (years)	0.017	0.001	20.556	<0.0005
Gender (female *vs* male)	0.023	0.020	1.160	0.24
Hospital 1	0.064	0.016	19	<0.0005
Hospital 2	0.015	0.018	0.808	0.41
Season 1 (January–March)	0.005	0.017		
Season 2 (April–June)	0.006	0.018	1.28	0.27
Season 3 (July–September)	0.034	0.018		
Year of surgery	0.002	0.002	1.168	0.32

Dependent variable, mortality; hospital 1, smaller hospitals (0–399 beds) in comparison with larger hospitals (>400 beds); hospital 2, university hospitals in comparison with larger hospitals (>400 beds); season 1, 2 and 3, with respect to October–December as reference.

In this study, the type of hospital class had a significant influence on in-hospital mortality. The lowest mortality was found in the smaller hospitals (0–399 beds) and the highest in University Hospitals. Zdanowski *et al.* describe differences in mortality between the university hospital and the county hospitals,[11] where in-hospital mortality was higher in the county hospitals, although these differences were

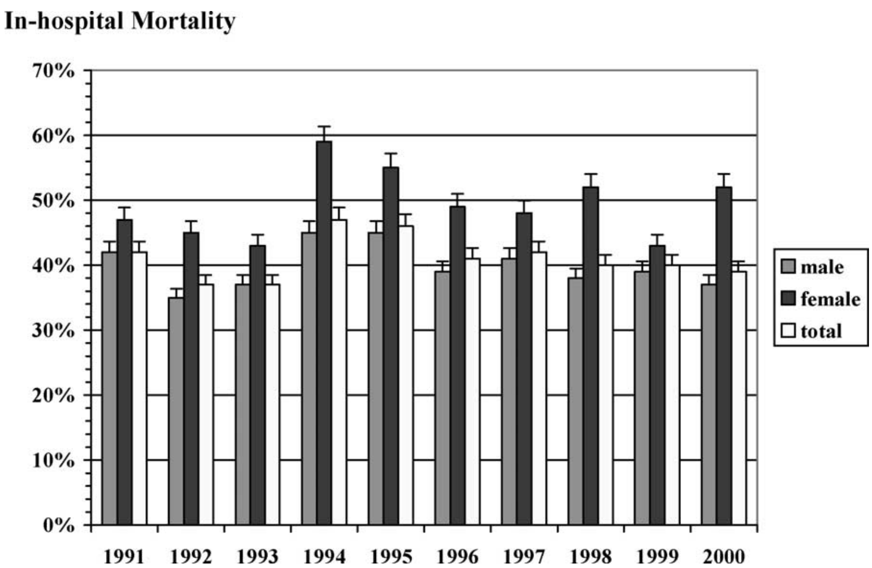

Fig. 2. In-hospital mortality in 5593 patients following ruptured infrarenal abdominal aortic aneurysm repair over a decade. Bars represent the 95% confidence intervals.

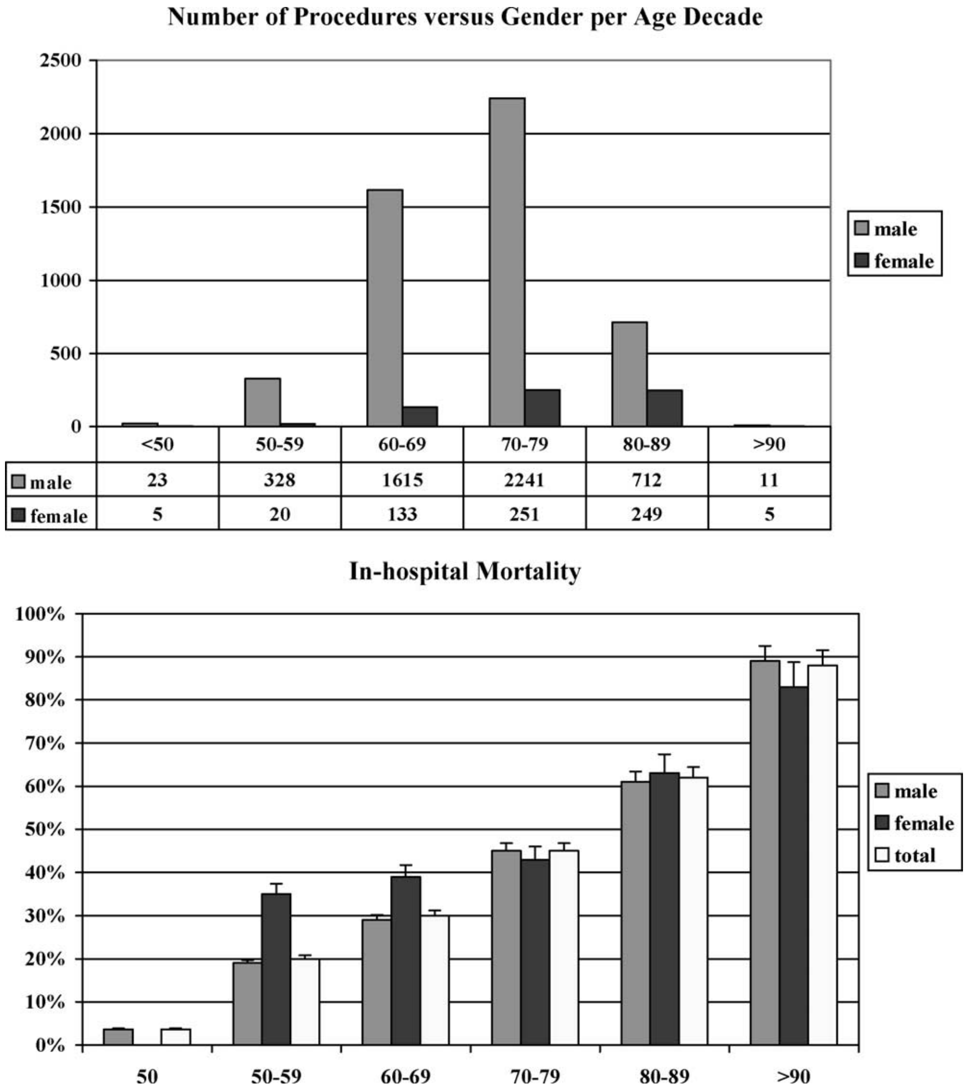

Fig. 3. Number (upper diagram) and mortality (lower diagram) of 5593 ruptured infrarenal abdominal aortic aneurysm repairs between 1991 and 2000 related to different age groups. Bars represent the 95% confidence intervals.

not significant. Higher mortality in the county hospitals seemed to be related to the post-operative phase. Rutledge *et al.* found that patients who underwent surgery in smaller hospitals had significantly lower survival rates than patients who underwent surgery at larger hospitals.[5] However, they define larger hospitals as over 100 beds. The difference we found in mortality between the different hospital classes could not be explained by differences in age or gender distribution. An explanation for the difference could be that it is not uncommon to refer high-risk patients to larger or university hospitals for treatment, even for cases of rupture. Furthermore, pre-operative selection of patients eligible for open repair of RAAA is expected to be less strict in larger or university hospitals.

Mortality increased with age in both univariate and multivariate analysis. The mean age at the time of surgery in women was higher than in men. This age difference might be explained by the assumption in women, aneurysm development occurs at an older age and, therefore, rupture occurs later. Furthermore, the increased age of women at rupture might explain, at least partially, the fact that gender was not of significant influence on mortality in multivariate analysis. Evans *et al.* also describe the absence of influence of gender on either short-term or long-term outcome.[10] However, they do suggest that women are less likely to be selected for surgery than are men, because women are thought to have a higher operative risk. Rutledge *et al.* described a significantly higher mortality rate in women, but they also suggested the

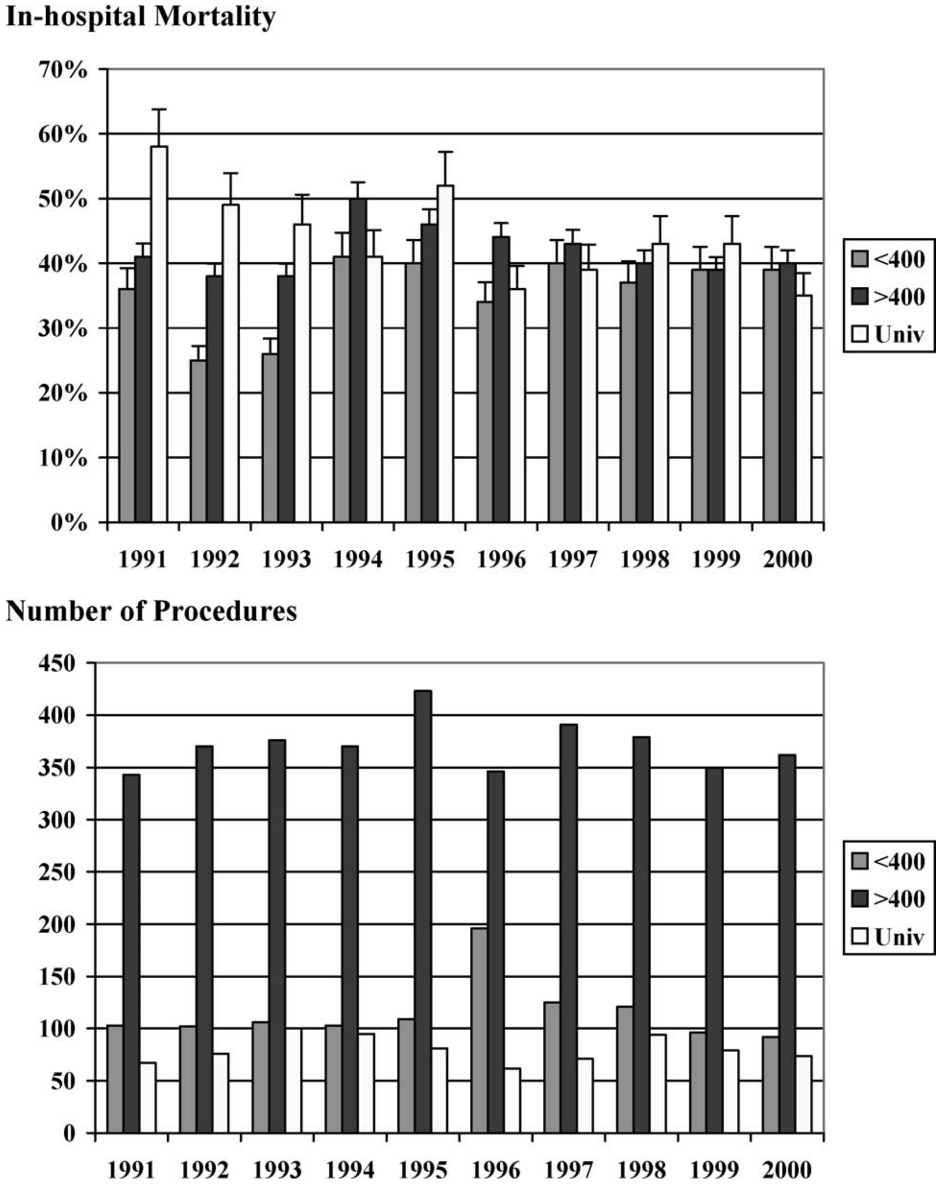

Fig. 4. In-hospital mortality in 5593 patients (upper diagram) and number of procedures (lower diagram) following ruptured infrarenal abdominal aortic aneurysm repair over a decade, regarding the type of hospital in which treatment was performed (0–399 beds, ≥400 beds; University Hospitals). Bars represent 95% confidence intervals.

possibility of a gender bias in the diagnosis or selection for surgical treatment.[5]

A seasonal variation in the incidence of rupture of AAA has been suggested by Castleden *et al.*[13]. They found a highly significant correlation between sudden death from RAAA and the winter months in Western Australia, which they explained by temperature-induced changes in blood pressure. Varty *et al.*[14] found a peak incidence in AAA rupture in spring and autumn, possibly explained by heamodynamic adjustments to changes in climate. Furthermore, Bown *et al.*[15] suggest an association between AAA rupture and low atmospheric pressure. However, like Johansson *et al.*[17] we could not find a seasonal variation to support any of these findings. In this study, the number of procedures did not change significantly over the four seasons. Although the in-hospital mortality was higher in the summer, in multivariate analysis, no seasonal influence on operative mortality was found.

We conclude that over a 10-year period, in a nationwide study, there were no significant temporal changes of in-hospital operative mortality of RAAA. We found age and hospital type to be the most significant predictors of mortality, although we acknowledge the limitations of a retrospective analysis of national registry data.

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No conflict of interest is identified.

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