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Infrarenal abdominal aortic aneurysm

-comorbidity and results following open surgery

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Content

Acknowledgements……………………………………………………3

List of papers………………………………………………………….5

Abbreviations…………………………………………………………6

Introduction ………………………………………………………..7

Study objectives……………………………………………………10

Methodological considerations……………………………………12

Summary of results………………………………………………...15

General discussion…………………………………………………20

Conclusions………………………………………………………….26

References…………………………………………………………..27

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List of papers

This thesis consists of the following publications, which will be referred to by roman numerals:

I Egeberg T, Haug ES, Thoresen JEK, Myhre HO. Concomitant intra-abdominal disease in aortic surgery. Eur J Vasc Endovasc Surg 1997; 14 (Supplement A), 18-23

II Haug ES, Skomsvoll JF, Jacobsen G, Halvorsen T, Sæther OD, Myhre HO. Inflammatory Aortic Aneurysm is associated with an increased incidence of autoimmune diseases. J Vasc Surg 2003; 38: 492-7

III Haug ES, Romundstad P, Aadahl P, Myhre HO. Emergency non-ruptured abdominal aortic aneurysm. Eur J Vasc Endovasc Surg 2004; 28: 612-18

IV Haug ES, Romundstad P, Aune S, Hayes TBJ, Myhre HO. Elective open operation for abdominal aortic aneurysm in octogenarians - Survival analysis of 105 patients. In press Eur J Vasc Endovasc Surg.

V Haug ES, Romundstad P, Sæther OD, Jørgenvåg R, Myhre HO. Quality of data reported on abdominal aortic aneurysm repair - A comparison between a national vascular and a national administrative registry. In press Eur J Vasc Endovasc Surg.

VI Haug ES, Romundstad PR, Lundbom J, Myhre HO. Infrarenal abdominal aortic aneurysm repair; Trends and results during a 20-year period. Manuscript

Abbreviations

AAA:	Abdominal aortic aneurysm
ACB:	Aorto-coronary bypass
CHD:	Congestive heart disease
CHF:	Congestive heart failure
COPD:	Chronic obstructive pulmonary disease
CT:	Computed tomography scan
EVAR:	Endovascular aortic aneurysm repair
IAA:	Inflammatory aortic aneurysm
ICU:	Intensive care unit
MI:	Myocardial infarction
NS:	Not significant
NPR:	Norwegian Patient Registry
NYHA:	New York Heart Association
RCT:	Randomised clinical trials
30d:	Thirty day (mortality),
US:	Ultrasound

Introduction

Although definitions based on fixed diameters have been proposed, an aneurysm of the abdominal aorta is mainly defined as a dilatation with at least 50% increase in diameter compared to the expected normal diameter of an adjacent unaffected part of the aorta (Johnston KW et al 1991). The dilatation is caused by a degradation of elastic fibres in the arterial wall, which make the aortic diameter increase as the process is progressing. The dilatation may cause rupture of the aorta with fatal haemorrhage as result.

With a few exceptions, AAA is thought to be of atherosclerotic origin. An AAA has according to some authors always some degree of aortic wall inflammation, but in approximately 5% of the patients, thickened aneurysm wall is reported. Further, there may be perianeurysmal fibrosis and dense adhesions to the duodenum (Walker DI et al 1972). The condition is then named IAA, which is though by several authors to be a separate disease entity. The condition is associated with more intraoperative technical problems and many of the patients have hydronephrosis with impairment of the renal function due to obstruction of the urethers caused by the fibrosis.

Studies have shown that male gender, age, smoking, atherosclerotic disease and a positive family history are independent risk factors for AAA, while there is more controversy about the association with other risk factors for atherosclerosis like hypertension and hypercholesterolemia. The total rate of AAA in a large Swedish autopsy study was 4.3% for men and 2.1% for women (Bengtsson H et al 1992). The prevalence was increasing during the study period and with age, reaching a peak in men (5.9%) at the age of 80 and after 90 years in women (4.5%).

Women on the other hand have a 3-4-fold increased risk of rupture and female gender is associated with increased risk of death after rupture (Cronenwett JL and Johnston KW 1999, Brown LC and Powell JT 1999, Stenbaek J et al 2004). It has also been demonstrated that women are less likely to be admitted to hospital and selected for operation for ruptured AAA than men (Semmens JB et al 2000). Furthermore, studies on repair of non-ruptured AAA have shown that female gender is associated with higher early mortality and lower long-term survival (Menard MT et al 2003, Stenbaek J et al 2004). In recent studies there has been an understanding that women tend to have smaller aortas (Pedersen OM et al 1993) and that the aneurysm diameter as indication for treatment should be smaller for women than for men (Heikkinen M et al 2002).

The first published AAA resection with reestablishment of vascular continuity by a preserved human arterial graft was done by Charles Dubost at Broussais Hospital, Paris, France, 31. March 1951 (Dubost C et al 1952). Later, treatment with aneurysm resection and the implantation of synthetic vascular grafts has become standard. In 1991 Parodi and colleagues and Volodos and colleagues performed the first endovascular repairs of AAA, and as the method has been improved, EVAR has been used in an increasing number of patients (Parodi JC et al 1991, Volodos NL et al 1991).

The early mortality (30d) after open emergency repair for AAA is still high, with 30-60% (Bayly PJM et al 2001, Heller JA et al 2000) mortality for patients with ruptured AAA, while mortality numbers following elective repair range from 0-8% (Brewster DC et al 2003, Blankensteijn JD et al 1998). A review of 64 published series showed a weighted mean 30d mortality of 5.5% for elective operations (Hallin A et al 2001). In 48 studies the weighted mean 30d mortality was 47.2% for emergency operations, and nearly all were performed for ruptured aneurysm. Although there have been several technical problems with the endoprostheses, early morbidity and mortality seems to be lower compared to open repair and high-risk as well as elderly patients have been claimed especially suitable for EVAR (Greenhalgh RM et al 2004, Sicard GA et al 2001, Prinssen M et al 2004).

AAA is most often an expression of a generalized atherosclerotic disease, and the patients therefore often have a high prevalence of comorbidity. Coronary heart disease, hypertension, intermittent claudication, cerebrovascular disease, renal failure and COPD are all diseases that that can impair the patient's life expectancy and some have shown to be associated with increased perioperative mortality (Johnston KW 1989). The recording of risk factors among the operated patients is also a crucial part of case-mix evaluation when comparing results from different centers. Meta-analyses performed by Steyerberg and colleagues have demonstrated that Serum Creatinin> 1.8mg/dL and CHD are the independent risk factors with the highest risk of perioperative mortality after elective AAA repair, with Odds ratios of 3.3 and 2.3 respectively (Steyerberg EW et al 1995). Knowing the comorbidity and life expectancy of patients as well as the operative results of the department is therefore mandatory to make a recommendation regarding treatment for AAA.

Study objectives

Paper I

The aim was to study the occurrence and treatment of concomitant intra-abdominal disease and their influence of on results after operation, in a cohort of patients treated for infrarenal AAA.

Paper II

The aim was to investigate whether there was a higher incidence of autoimmune diseases in patients with IAA.

Paper III

The purpose was to investigate if symptoms, type of admission (elective vs. emergency) and timing of surgery influenced early mortality (<30d) in patients operated on for non-ruptured symptomatic AAA.

Paper IV

To study early mortality, long-term survival and relative survival in patients aged 80 years or more who were treated electively with open operation for AAA.

Paper V

To study quality of data on treatment for AAA in a national vascular registry (NorKar) and a national administrative registry (NPR). Further we wanted to evaluate our inclusion criteria when searching for AAA-procedures in medical registries.

Paper VI

The object was to study changes in treatment for AAA in a university hospital over a twenty year time span with focus on patient volume, mortality and use of resources.

Methodological considerations

The papers presented in this thesis are based on historical cohort studies of patients operated for AAA from 1983 to 2002. The patients have been followed over a time span from two to twenty years. The studies are mainly based on patients operated for AAA at the Department of Surgery, St. Olavs Hospital, but two of the studies also include patients from other Norwegian hospitals (Paper IV and V). Paper IV was performed as a multi-center study to include enough patients to raise statistical power.

St Olavs hospital is the only hospital in the county of Sør-Trøndelag performing vascular surgery, and is also a referral hospital for two neighbour counties. In the studies from our hospital we corrected for home-county of the patients, but found no measurable difference in the results. Thus, in addition to being hospital based, study I, II, III and VI, can also be considered as population based for the county of Sør-Trøndelag when excluding the patients referred from Nord-Trøndelag and Møre & Romsdal (Blankensteijn JD et al 1998).

In Paper I, patients were included before the end of 1994 and before our database was completed by quality assessment. This is the reason for the lower number of patients, 459, in this paper. A review of the medical records of the remaining 61 patients operated 1983-1994 did not alter the prevalence of concomitant diseases or the conclusions.

An advantage of our single-centre studies is that there has been a thorough inclusion and follow-up of all patients, and that the material is close to complete. In this way inclusion-bias related to missing patients is minimized.

However, studies based on historical data have weaknesses in the evaluation of risk factors, especially when based on anamnestic data only. None of the patients in these studies have been diagnosed with standardised tests on comorbidity for the purpose of this study, but a thorough evaluation of all available data from the medical records has been performed. Definitions have been based on objective data as far as possible, e.g. medication for COPD and hypertension, serum-creatinin level of more than 140 μmol/L in renal failure and positive information on symptoms and smoking. IAA was registered according to an accepted definition by the presence of a thickened aneurysm wall, extensive perianeurysmal and retroperitoneal fibrosis and dense adhesions to adjacent abdominal organs (Rasmussen TE et al 1999). All objective data from the medical record like operating time, results of blood samples, time in ICU and hospital, as well as survival, have been checked against hospital and public registries. Still as shown in a recent paper, completeness of medical record documentation may vary with the urgency of admittance, and may have contributed to some of the differences observed in Paper III (Lewis DR et al 2003). Follow up was performed by checking patients against the Norwegian Registrar's Office of Births and Deaths, which is updated every 14 days, and by collecting information from the local district hospital of the patients.

There will always be selection of patients in a non-randomized clinical study depending on decisions made by the operating surgeons, available diagnostic and therapeutic modalities and on properties of the patients. This selection could influence the outcome, and thus constitute a threat against causal interpretation of the results. Although multivariate analyses have been used to control for potential confounding, observational comparisons between different treatment modalities will always be at risk of influence by unmeasured confounders.
Still the results may reveal associations and hypotheses that can be further tested by RCT, and although randomized trials are well suited to estimate causal associations and effects, observational studies have the ability to document daily clinical practice. Retrospective

studies may also constitute an acceptable study design when studying rare conditions, like IAA in Paper II.

Summary of results

Paper I.

In 12 (2.6 %) of 459 patients, concomitant malignancies in colon or the urogenital system were discovered in connection with diagnosis and treatment for AAA. In 10 cases the AAA was treated as a secondary procedure, with no early morbidity or mortality. One high risk patient was operated with simultaneous AAA-resection and nephrectomi. A second patient with assumed impending rupture turned out to have metastasis from a renal tumour. Both died within 11 days of the operation from MI.

Asymptomatic cholelithiasis was not systematically recorded among patients treated for AAA, but 5 patients had cholecystitis, one had iatrogenic rupture of his AAA at laparoscopic cholecystectomy and the aneurysm of one further patient ruptured while waiting for surgery of a fistula between the colon and the gallbladder. The five patients had surgery for both conditions and the latter two had their gallbladder intact. Cholecystectomy was performed separately prior to aneurysm resection except in one case where the procedures were performed simultaneously. Of the patients who were operated with cholecystectomy, two died from occlusion of the superior mesenteric artery on the 6^{th} postoperative day and none survived more than 3 years.

Paper II

The prevalence of autoimmune diseases in 31 patients with inflammatory aortic aneurysm (IAA) was 19% compared to none (p=0.0017) in a matched control group within the cohort of patients operated on for AAA. There were; 2 cases of rheumatoid arthritis, 2 cases of systemic lupus erythematosus, 1 had giant cell arthritis and 1 patient had seronegative polyarthritis

diagnosed as rheumatoid arthritis. The autoimmune diseases were classified according to accepted criteria (Arnett FC et al 1988, Tan EM et al 1982, Hunder GG et al 1990).
Median wall thickness of the aneurysm was 11.2 mm in the IAA-group. Involvement of the duodenum was the most common complication of IAA, and 26% had hydronephrosis due to uretheral obstruction. Median ESR was almost doubled in IAA-patients compared to the control group. Patients with IAA seemed to have higher need for blood transfusion and longer operating time, while stay in ICU, hospital stay and early mortality was similar in the two groups.

Paper III

129 patients were admitted to hospital as emergencies because of symptoms related to a non-ruptured AAA. In 61 patients operated on as emergencies (within 24 hours of an emergency admittance) for non-ruptured AAA, mortality (30d) was 18.0% compared to 4.2% in 68 patients operated semi-electively (later than 24 hours after an emergency admittance) and 239 elective patients with non-ruptured AAA. The presence and number of symptoms did not show any significant correlation to early mortality. Four patients previously turned down for elective operation all died following emergency operation for non-ruptured AAA. One additional patient previously found unfit for surgery survived a semi-elective operation. Emergency patients showed a clear tendency of more coronary heart disease and significantly more of the patients were categorized as 3 and 4 according to the NYHA-classification. Interestingly more elective patients were reported to have hypertension and intermittent claudication. There was a tendency towards more women among patients admitted as emergencies without rupture than patients operated electively.

Paper IV

Overall early mortality in this series of 105 consecutive octogenarians operated electively for AAA was 10.9%. Although comparisons on gender and age failed to show any significant differences, men and patients more than 84 years of age had a relative high early mortality, 11% and 16.7% respectively. 30d mortality for women was 8.7% and their relative 5-year survival was 101% compared to 81% for men. Octogenarians seemed to have long-term survival comparable to an age matched control group with a median 5-year survival of 47%. For patients aged 84 years or more, median survival was 35 months. Cardiac complications were the most common cause of early death and mortality did not change during the study period.

Hypertension and cardiac conditions were the most common comorbidities but more men than women had preoperative renal failure. The complication rates seemed fair, but 12 patients were reoperated, nine due to haemorrhage. Median postoperative hospital stay was 9 days and 14 patients needed ventilatory support for more than one day.

Paper V

The comparison between the national vascular registry (NorKar) and the national administrative registry (NPR) showed that NPR is probably more complete for patients treated for AAA nationwide. The reason is that hospitals that are not members of NorKar report to NPR, but also that more patients were reported to NPR than to NorKar for member hospitals. The completeness of AAA treatments in NorKar was 84%, compared to NPR. The investigation further showed that there was lack of Procedure-Diagnosis-consistency in 7% of the patients in both registries, showing that the codes for procedure and diagnosis did not match. Relative to NPR numbers only 60% of patients who died in hospital after operation for AAA were reported to NorKar. Corrected for the overall completeness of reporting for each hospital, only 72.3% (CI; 65.2, 79.4) of early deaths were reported to NorKar. The reason for this systematically underreporting could not be assessed. The crude national in-hospital mortality was 33.7% for ruptured and 5.0% for non-ruptured AAA, while the crude NorKar mortality numbers were 29.9% and 3.1% respectively.

A detailed evaluation of one NorKar Local Registry using all available registries and the medical records of the member hospital, showed that the completeness was 91.3%, and that 5.3% of the registered cases were falsely coded or doublets.

Paper VI

From 1983 to 2002, 1045 patients were treated for AAA at St. Olavs Hospital, University Hospital of Trondheim. We observed an increasing number of elective operations in each 5-year period. While operations for both non-ruptured and ruptured AAA increased in men, there was only a steady increase in operations for ruptured AAA in women. Simultaneously, the use of bifurcated vascular grafts declined compared to tube grafts. Although the number of emergency operations has increased, the number of emergency operations for non-ruptured AAA has declined during the period. Since its introduction in 1995, EVAR is preferred in an increasing proportion of patients.

The median operation time and anaesthesia time increased with more than one hour during the first decade and has been stable since then. 30d mortality was 41.6% for ruptured, 18.9 for emergency non-ruptured and 4.8% for elective operations. Although women had a slightly lower 30d mortality following elective operation compared to men (3.0% vs. 5.1%, NS), women had a higher mortality after operation for ruptured AAA, 57.1% and 37.4% respectively. Five-year survival was inferior in women after AAA repair and especially for those with ruptured AAA (24.3% vs. 41.3%). In logistic and Cox' regression, factors influencing 30d and long-term mortality were age at operation, cerebrovascular disease and renal failure. Long-term survival was further impaired by COPD, diabetes and that the operation was performed before 1993.

General discussion

The papers in this thesis have mainly focused on patients operated for non-ruptured AAA. In ruptured AAA mortality is 100% if the condition is not treated. The purpose of surgery for the two categories of patients is quite different. While the indication for surgery is vital in patients with rupture, the operation is prophylactic in patients with no signs of rupture.

In paper I we showed that performing AAA repair as a secondary procedure after an operation for malignancy did not result in postoperative mortality or serious morbidity in our study population. Other studies have shown that AAA and gastric or colorectal malignancies can safely be treated with one stage operation in selected patients (Matsumoto K et al 2002, Georgopoulos S et al 2004, Oshodi TO et al 2000, Baxter NN et al 2002), and concomitant AAA and carcinoma of the bladder have also been treated simultaneously with success in one study (Grego F et al 2003). A recent review has further proposed that synchronous aortic and gastrointestinal surgery should be performed when urgent surgery for both conditions is indicated (Tilney HS et al 2002). We feel that in an elective situation, the risk of graft contamination from a colorectal procedure still make us choose a staged procedure, with priority for the symptomatic or the most threatening condition.

We had no cases of colon necrosis in the 6 patients operated for concomitant colorectal cancer. Colonic resection will impair the arterial supply to the colon by ligation of collateral vessels. One of our indications for reimplanting a patent inferior mesenteric artery has been previous colon resection. The present study cannot evaluate the necessity of this procedure, but we have experienced fatal colon necrosis when the routine of reimplantation was not followed in one such case.

To operate the malignant disease first makes sense, because prophylactic aortic surgery has limited value if disseminated malignant disease is discovered in assessment of the cancer.

However in a patient with a large AAA and a small asymptomatic colon carcinoma we would recommend aortic surgery first.

The prognosis of the patients with cholecystitis was poor in this series, probably due to a high median age of 74 years. One can though not exclude the possibility that a sudden onset of cholecystitis in some patients is a sign of increased physiological vulnerability leading to high risk of death from various causes. Technical difficulties connected to a hostile abdomen after prior inflammation and surgery may increase the risk of open surgery and could be an indication for EVAR, provided the patient is suited from an anatomical point of view (Lee JT et al 2002).

With a definition of emergency operation as surgery performed within 24 hours of an emergency admittance, patients with non-ruptured AAA in this group seemed to have more risk factors than patients operated electively, as shown in Paper III. In the logistic regression in paper VI emergency operation had an odds ratio of 4.9 (2.4-9.9) for 30d mortality compared to elective operations. This is probably the most important reason for the observed difference in 30d mortality between emergency end elective patients. In paper VI we have demonstrated that less symptomatic patients have been operated as emergencies during recent years. Thus, the decrease in number of emergency operations for non-ruptured AAA over the period indicates a change in treatment policy at our department. It could also be the result of an increased availability and improved quality of CT scans that can rule out rupture. We hope that through this change in policy, early deaths may have been avoided by performing the operation under more elective conditions (VI) (Bell CM and Redelmeier DA 2001). A weakness of our study is that emergent admitted patients that were discharged without being operated, have not been primarily assessed. Most of them will still have been included in our cohort by later elective or emergency treatment.

Women have a 3-4 fold increase in risk of rupture of their aneurysm compared to men. (Brown LC and Powel JT 1999, Brown PM et al 2003). Still women are less likely to be operated for ruptured AAA (Evans SM et al 2000, Semmens JB et al 2000). Our study on octogenarians (Paper IV) indicated that women had slightly larger aneurysms, 68 to 65mm, but that men were median 1.5 years older. In addition to the increased proportion of women among emergency patients in Paper III, this indicates that women are less likely to be considered for elective surgery for AAA as well in our institution. This is also supported by the finding in Paper VI that there has been a small reduction in the proportion of women operated for non-ruptured AAA during the study period. The fact that women with AAA are at higher risk to die from rupture, and that the risk of rupture increases at a smaller aneurysm diameter than in men, probably calls for a more aggressive treatment policy in women with AAA (Heller JA et al 2000, Brown PM et al 2003).

The reduced long-term survival in women after treatment of AAA found in paper VI is difficult to explain and different views on this matter have been presented in the literature (Evans SM et al 2000, Semmens JB et al 2000). It is possible that AAA in women is associated with a more aggressive atherosclerotic disease (Solberg S et al 2005). In a population-based study women with AAA are also more likely to be current smokers than men (Pleumeekers HJ et al 1995). The fact that women in paper III had superior long-term survival may be the result of a stronger selection of low risk female octogenarians for operation compared to men, and the fact that they were on average 1.5 years younger than the men.

The introduction of EVAR in February 1995 at our department had implications for indication and preferred treatment for some of the patients. We have tried to compensate for this by including only patients operated 1983-94 in Paper I-III. In paper IV on octogenarians there may have been a selection bias since patients treated with EVAR were not included. Thus, the increase in the number of octogenarians treated would have been even higher, because elderly and high-risk patients more often have been offered EVAR instead of open repair. The benefit of operation must be evaluated based on annual risk of rupture, chance of survival after rupture and the risk of early death after a prophylactic operative treatment. The annual risk of rupture is related to the size of the aneurysm, but on this point there is substantial controversy among surgeons (Lederele FA et al 1996) and the results in different studies varies (Brewster DC et al 2003). A striking observation is that the cause of death in unoperated patients in these surveillance studies is ruptured AAA in only 30-50% of the cases, even when the aneurysm diameter was more than 65mm (Conway KP et al 2001). The perioperative mortality in our study on octogenarians with median aneurysm size of 65mm equals the annual rupture risk of aneurysms with a diameter of 65mm (BrewsterDC et al 2003). Without obtaining a substantial decrease in early mortality by improving open surgery, or by using EVAR to a greater extent, elective AAA treatment is questionable in octogenarians, especially in the oldest group and in those with co-morbidities.

The increased prevalence of autoimmune diseases among patients with IAA has to our knowledge not previously been reported (Paper II). Treatment of IAA is connected with technical challenges and this is reflected by the longer operating time in our study. The epidemiological association implies that in patients with known autoimmune disease and AAA, ESR-measurement and CT-scan should be performed in order to prepare the surgical team on difficulties connected to a possible IAA, and perhaps choose EVAR as an alternative. (Lange C et al 2005). Because IAA is discovered most often during the operation, introduction of EVAR may have as a consequence that fewer IAA are detected if the diagnosis is not made during interpretation of the CT scans.

AAA is usually an asymptomatic condition that in itself causes no physical impairment. Perioperative mortality, morbidity and late survival are therefore important elements for evaluation of the indication for and benefit from surgery for AAA. In our study on reporting to NPR and NorKar (V) it became evident that the sources of data were insufficient both on a national level but also for several hospitals. The finding of systematically under-reporting of in-hospital deaths in NorKar of 28% is a serious weakness of the national vascular registry that demands further investigation and correction. Although the reasons have not been assessed, a part of the explanation could be that patients dying after surgery are treated for their complications in other departments where the vascular registry is unknown. The lack of completeness of vascular registries has only sporadically been assessed or debated in publications, but it is a major challenge to get reliable data from such registries (Kantonen I et al 1997).

An interesting observation is that there was no association between hospital volume of AAA operations and early mortality. Although the university hospitals have the highest number of patients, the volume of each surgeon might still be just as large in a county hospital. The university hospitals further have obligations as training institutions with the consequence that many of the operations are performed by less skilled surgeons under supervision by a senior. This is most likely one of the explanations for the increase in operating time during the study period observed in Paper VI. We were not able to relate mortality rates to position of operating surgeon, but it must be a demand that the training situation is not affecting operating time, early mortality or complication rate (Evans SM et al 1999). Introduction of EVAR has negatively influenced the training situation for surgical residents regarding open AAA repair, since the volume of open operations is decreasing simultaneously with an increasing complexity of the surgical cases (Sternbergh WC 3rd et al 2002). Continuous surveillance of the mortality and complication rate of training centres by a vascular registry is necessary for the documentation of a high standard of results and patient safety. Our study (V) has also demonstrated that a national administrative registry has an important function as a corrective for a vascular registry. Improvement of both registries can probably be achieved by comparison on individual patient-level.

Conclusions

- Repair of AAA as a secondary procedure did not result in high postoperative mortality or serious morbidity in a cohort of patients operated for concomitant colon or renal malignancies, but patients with concomitant cholecystitis had inferior long-term survival.
- IAA is in our study associated with increased incidence of autoimmune diseases, but further investigation is needed to explore the nature of this association.
- Patients admitted and operated as emergencies with non-ruptured AAA seem to have a higher prevalence of co-morbidities, and emergency operation may contribute to higher 30d mortality in these patients.
- Octogenarians treated electively with open operation for AAA have comparable long-term survival with a matched normal population. However, operation seems questionable especially in the oldest patients due to high early (30d) mortality.
- Lack of consistency and completeness of reported data, especially reduced relative completeness of reporting early deaths after AAA-treatment in the national vascular registry, calls for strategies in quality assessment including person identifiable data.
- Over twenty years there has been an increase in operating time for AAA that may be due to increased educational load in our hospital. A relative decrease in proportion of women operated electively is not in consistency with the increased risk of rupture and death after rupture related to female gender, and calls for further analysis.

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Paper I

Eur J Vasc Endovasc Surg **14** (Supplement A), 18–23 (1997)

Concomitant Intra-abdominal Disease in Aortic Surgery

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Introduction

Concomitant intra-abdominal diseases can significantly influence the prognosis in patients with abdominal aortic aneurysms and have major impact on the planning and technical performance of aneurysm repair. Although the topic has been discussed for decades, questions as to which disease should have priority and the influence on the outcome of treatment are still controversial.[1,2] One explanation is that each centre will only be able to accumulate limited experience with this specific combination of diseases. One of the most frequent conditions seen in this context is carcinoma of the colon. Malignancies in the urogenital system are included in this survey, as they may represent special problems. Furthermore, cholelithiasis and cholecystitis are seen occasionally. Diverticulitis of the colon and other inflammatory bowel diseases may be observed in rare cases. The purpose of this article is to review a series of patients operated on for infrarenal abdominal aortic aneurysm (AAA) and to analyse the occurrence of concomitant intra-abdominal diseases, including its influence on complication rate and final outcome.

Materials and Methods

During the period January 1 1983 to December 31 1993, 459 patients were operated on consecutively for infrarenal AAA. Twenty-one percent of the patients were referred from other hospitals because of complicating diseases or anticipated technical problems with the operation. In this investigation we have defined concomitant intra-abdominal disease as that detected during diagnostic examination for a known AAA, or detected during an operation performed with the intention to repair the aneurysm. In other cases the aneurysm was detected during surgery for another intra-abdominal disease. During aneurysm repair, inspection and palpation of intra-abdominal organs should be routine. Although this part of the procedure may be less than optimal in patients with ruptured aneurysm, we have decided to calculate the incidence of concomitant disease by including all 459 patients.

The investigation was performed retrospectively. Prior to elective operations, aortography was carried out in all cases, whereas ultrasound examination or CT scan were only performed for special indications. All patients were operated on under general anaesthesia using a midline laparotomy incision. Inspection and palpation of intra-abdominal organs was performed and the findings noted in the operating report.[3]

Regular postoperative complications, although included in the investigation, are not discussed further with the exception of postoperative cholecystitis. Furthermore, it is outside the scope of this article to discuss concomitant vascular diseases such as obstruction of the mesenteric or renal arteries. Some conditions affecting the urogenital system are included because they may represent special problems. No systematic follow-up was performed in this investigation, but most patients have been followed in the outpatient clinic. The mean follow-up period was 2.5 years. In patients with concomitant disease a complete follow-up investigation was performed.

Results

Malignancies

The series included six patients with colorectal cancer (1.3%). All patients, with one exception, had symptoms or signs associated with their bowel disease (Table 1).

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Table 1. Concomitant colorectal cancer and abdominal aortic aneurysm.

Age	Sex	Symptoms	Aneurysm diameter (cm)	Dukes' stage of the carcinoma	Location of tumour	First operation	Interval from first to second operation (months)	Outcome
72	F	Abdominal pain	4.5	C	Right flexure	Right hemicolectomy, right nephrectomy, duodenal resection	7	Alive after 5 years without recurrence
65	M	Haemorrhagic diarrhoea	4.5	B	Rectum	Low anterior resection	4	Alive after 6 years, no recurrence
72	M	Abdominal pain, rectal haemorrhage	6.0	A	Rectum	Abdominoperineal resection, sigmoidostomy	1.5	Died 4.5 years postoperatively from myocardial infarction
71	M	Pain in the right fossa, diarrhoea	4.5*	B	Ascending colon	Right hemicolectomy	4	Alive after 4 years without recurrence
58	M	Abdominal pain, weight loss	5.0	C	Sigmoid colon	Resection of the sigmoid colon	2	Died after 1.5 years from metastasis
81	M	Anaemia abdominal tumour	7.0†	B	Multiple tumours in the caecum, ascending and transverse colon	Subtotal colectomy	5.5	Alive after 10 years without recurrence

* Had additional aneurysm of the common femoral artery with a diameter of 2.5 cm.
† Had large aneurysms of the iliac arteries bilaterally.

Three patients had both conditions diagnosed prior to operation, whereas AAA was detected during an operation for cancer in two, and in one patient a locally advanced cancer (Dukes stage C) in the right colon was discovered during a planned AAA repair. In two patients the carcinoma was located in the rectum, two had involvement of the right colon and one of the sigmoid colon, whereas one had multiple cancers affecting both the right and transverse part of the colon. One of the patients with rectal carcinoma was treated by abdominoperineal resection and sigmoidostomy, whereas a low anterior resection was possible in the other patient. Histologically two tumours were classified as Dukes stage C, three as Dukes B and one as Dukes A. In all patients the carcinoma was given priority and AAA repair was performed as a staged procedure. For both operations a transperitoneal approach was applied. No complications occurred in this group of patients. In one patient the inferior mesenteric artery was patent and therefore reimplanted into the graft. One patient died 1.5 years after the last operation due to metastasis from a Dukes C cancer in the sigmoid colon, and one died 4.5 years later of myocardial infarction. The rest of the patients are alive from 4 to 10 years postoperatively.

Four patients had concomitant renal carcinoma (0.9%). In one patient both conditions were operated during the same procedure, which included a right aortorenal bypass and resection of the left kidney (Table 2). Preoperatively this patient was regarded as a high risk case due to severe coronary heart disease and uraemia, and he died 6 h postoperatively. Two other patients had their renal carcinoma detected during preoperative examinations for AAA. In both cases nephrectomy only was performed during the first operation, and it was the original plan to leave the aneurysm unoperated. However, the aneurysms were operated on 8 and 12 months later, respectively, due to pain and increasing size of the aneurysm. Both patients are alive without symptoms 4 and 8 years after the last operation. In one patient with assumed impending rupture of a known aortic aneurysm, renal carcinoma and lymph node metastasis were detected during the aneurysm repair.

Two patients suffered from carcinoma of the urinary bladder (0.4%). The condition was detected prior to AAA repair and treated by transurethal electrocoagulation. Both patients were later operated on for their aneurysm with intervals of 1 and 6 months, respectively. One patient died 5 years later from haemorrhage caused by a fistula between the right graft limb and the coecum. Primarily this patient was operated on for an inflammatory aneurysm causing uraemia due to obstruction of the ureters. Prior to operation he had a transitional cell cancer in the bladder (stage WHO I) successfully treated with transurethral electrocoagulation. The other patient is still alive 11 years following aneurysm repair.

Table 2. Concomitant pre- and intraoperative cholecystitis and abdominal aortic aneurysm.

Age	Sex	Aneurysm diameter (cm)	First operation	Complication	Second operation	Outcome
83	M	8.0	Cholecystectomy	Suprahepatic abscess percutaneous drainage	Y-graft 2.5 months later	Died 1 year later from myocardial infarction
67	F	3.5*	Cholecystectomy	None	Aortobifemoral bypass 1 month later (critical limb ischaemia)	Succumbed on the 6th postoperative day from mesenteric artery thrombosis
74	M	5.0	Cholecystectomy	None	I-graft 1.5 months later	Developed renal insufficiency and died 3 years later from myocardial infarction
76	M	9.5	Common bile duct stone and cholecystitis. ERCP. 6 days later Y-graft implant and cholecystectomy	None	None	Died 3 years later from unknown cause
63	F	4.0†	Cholecystectomy	None	Y-graft. Revascularisation left limb	Died on the 6th postoperative day from mesenterial artery thrombosis
73	F	3.9	I-prosthesis. Iatrogenic damage of AAA during attempted laparoscopic cholecystectomy	None	None	Alive 2.5 years without symptoms
82	M	5.5‡	Y-prosthesis	Diagnosed stone in the common bile duct and fistula between colon and the gall bladder. The aneurysm ruptured while admitted for surgery of the fistula	None	Died from myocardial infarction 1 year later following laparotomy for intestinal obstruction caused by adhesions

* The patient had gangrene and rest pain from aortoiliac obstruction, which was the indication for aortic surgery.
† Critical ischaemia left limb.
‡ Operated on for ruptured aneurysm.

To conclude, a total of 11 patients (2.4%) had concomitant carcinoma of the colon or the urogenital system and in all cases it was decided to treat the aneurysm in a second procedure. No complications were recorded as a result of this policy.

Cholelithiasis/cholecystitis

In this series, asymptomatic cholelithiasis was not recorded. Five patients had cholecystitis prior to a planned operation for AAA. In all cases, with one exception, cholecystectomy was carried out primarily and the aneurysm repair performed as a staged procedure with an interval from 1 to 2.5 months. One patient was treated by a combined procedure. First the aneurysm was repaired, followed by closure of the peritoneum. Thereafter cholecystectomy was carried out. The cholecystitis, which was caused by a common bile duct stone, was resolving following ERCP and papillotomy prior to the operation. One patient with AAA had a stone in the common bile duct and a fistula between the gall bladder and the colon. Surgery for the latter condition was planned, but the aneurysm ruptured and an acute operation became necessary. One year later the patient succumbed from myocardial infarction following an operation for adhesions causing intestinal obstruction. Another patient had a known AAA with a diameter of 3.9 cm without indication for surgery. She also had symptomatic cholelithiasis and was scheduled for laparoscopic cholecystectomy. During the operation a troacar perforated the aneurysmal sac requiring immediate laparotomy, aneurysm resection and implantation of a vascular graft. Her cholelithiasis is still unoperated and the patient is asymptomatic 2.5 years after the operation (Table 3).

In summary, five patients were operated on for both conditions, whereas two patients had aneurysm repair only. The prognosis in patients with cholecystitis seems rather serious because only one patient was alive without having her gall bladder removed. Most of difficult on the right side, where a laparotomy is preferred. In patients with carcinoma of the urinary bladder, transurethral treatment is performed as a first procedure whenever possible. If there are indications for a radical cystectomy, it is recommended that aneurysm repair is carried out first.[14] An indication for this approach is that staging of the retroperitoneal lymph nodes can then be performed simultaneously. This procedure will not be technically possible after the aneurysm has been repaired. If extensive metastasis to the lymph nodes are found during the staging procedure, a radical cystectomy may be unnecessary.

In this series the incidence of asymptomatic cholelithiasis was not recorded. The occurrence of various conditions may also have been underestimated in patients with ruptured aneurysm who are often haemodynamically unstable, and a thorough evaluation of the intra-abdominal organs may have been minimised or neglected to reduce the operating time. In total, we observed three patients with postoperative cholecystitis, two of which had known cholelithiasis. All of these patients survived without further symptoms. We feel that it is unjustified to remove an asymptomatic gall bladder containing stones during AAA repair due to the possibility of increasing the risk of graft infection. Furthermore, the risk of postoperative cholecystitis is probably small and the prognosis seems good if this complication occurs.[15] Finally, about one-third of postoperative cholecystitis are likely to be acalculous, and these cases cannot be identified pre- or intraoperatively. If, on the other hand, cholecystitis or cholelithiasis causing recent symptoms is diagnosed before a planned operation for AAA, or is detected intraoperatively, cholecystectomy should be carried out as the primary procedure in most cases due to increased risk of graft infection.[16,17] If there is a high risk that the aneurysm may rupture in the near future, for instance in patients with large aneurysms or in those having pain due to expansion, one might decide to perform a combined procedure. Following surgery for cholecystitis, an interval of at least 14 days is needed before aneurysm repair is undertaken.

A possibility which should be investigated in patients having concomitant intra-abdominal disease is whether endovascular treatment of the aneurysm is technically possible.[4] One advantage with this method is that a second laparotomy is avoided, which could be advantageous if the first operation was performed because of intra-abdominal infection. A potential disadvantage with endovascular surgery is that the possibility of exploring intra-abdominal organs is absent. Therefore conditions like cholelithiasis or gastrointestinal cancer may not be diagnosed at the time of operation. Diverticulosis of the colon is often seen during operations for AAA. In general this condition can be neglected. However, diverticulitis must be treated before AAA repair is undertaken.[16,18]

Conclusion

In conclusion, 2.6% of patients in our study had gastrointestinal or urogenital cancer. In patients with colorectal cancer the symptomatic lesion should generally be treated first. In patients with cholecystitis or symptomatic cholelithiasis, cholecystectomy is indicated prior to operation for AAA unless the aneurysm is also symptomatic when a combined procedure is probably justified. Asymptomatic cholelithiasis found incidentally during an operation for AAA should be left alone, as the occurrence of postoperative cholecystitis in this series was low and the prognosis excellent with a conservative regimen. The possibility of applying endovascular aneurysm repair should be considered, as this technique may have special advantages in patients with concomitant intra-abdominal disease.

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Paper II

Inflammatory aortic aneurysm is associated with increased incidence of autoimmune disease

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Objective: **It has been suggested that certain genetic risk factors indicative of an autoimmune mechanism can be identified in patients with inflammatory aortic aneurysm (IAA). We therefore investigated whether there was a higher incidence of autoimmune diseases in patients with IAA. Further, we explored risk factors, need for in-hospital resources, and early results of treatment, in a case-control study in a university hospital setting.**

Material and methods: **From 1983 to 1994, 520 patients were operated because of abdominal aortic aneurysm (AAA). Thirty-one patients had IAA. Control subjects were matched for aneurysm rupture, emergency or elective hospital admission, and date of operation. Two noninflammatory AAA were included for every IAA.**

Results: **Of the 31 patients with IAA, 6 patients (19%) had autoimmune disease, compared with none of the control subjects ($P = .0017$). Two patients had rheumatoid arthritis, 2 patients had systemic lupus erythematosus, 1 had giant cell arteritis, and 1 patient had an undifferentiated seronegative polyarthritis diagnosed as rheumatoid arthritis. Nineteen patients (61%) with IAA had involvement of the duodenum, and 8 patients (26%) had hydronephrosis with ureteral involvement. Operating time was longer in the IAA group, which also had a higher need for blood transfusion. Hospital stay, intensive care unit stay, and 30-day mortality were similar in the two groups.**

Conclusion: **Except for longer operating time and more need for blood transfusions in the IAA group, use of hospital resources was similar after operations to treat IAA or noninflammatory AAA. The study findings indicate an association between IAA and autoimmune disease. This is in accordance with other reports that showed a genetic risk determinant mapped to the human leukocyte antigen (HLA) molecule in these patients. Further research is necessary to explore whether IAA might be a separate entity with a role of antigen binding in the origin of the disease. (J Vasc Surg 2003;38: 492-7.)**

Inflammatory aortic aneurysm (IAA) is a special variant of abdominal aortic aneurysm (AAA) first described by Walker et al.[1] Hydronephrosis in AAA, described by James[2] in 1935 and DeWeerd et al[3] in 1955, was probably caused by the same condition. Other investigators have stated that one can observe, to varying degree, the same type of inflammation in all atherosclerotic aneurysms.[4,5] IAA is characterized by a gray-white appearance observed during operation. Thickened aneurysm wall, perianeurysmal fibrosis, and dense adhesions to adjacent abdominal organs such as the duodenum and ureter are characteristic of IAA.[1,6] In particular, the anterior and lateral walls of the aneurysm are thickened, and the inflammatory tissue includes abundant infiltration of lymphocytes and plasma cells.[5,7,8] There is a similarity to idiopathic retroperitoneal fibrosis or periaortic fibrosis.[9] The histologic appearance of IAA is almost identical to giant cell arteritis.

The association between AAA, giant cell arteritis, and Takayasu disease has been described.[10] In contrast, Ehrenfeldt et al[11] did not find any association between aortic aneurysm or aortic dissection and occurrence of giant cell arteritis or polymyalgia rheumatica. In review of our cohort of AAA, it was striking that several patients with IAA had autoimmune disease, eg, rheumatoid arthritis, systemic lupus erythematosus (SLE), and giant cell arteritis. Further, it has been suggested that certain genetic risk factors can be identified in patients with IAA, indicating an autoimmune mechanism.[6,12]

The purpose of our study was to investigate whether there is a higher incidence of autoimmune disease in patients with IAA. Further we explored risk factors, need for in-hospital resources, and early results after treatment in patients with IAA compared with patients with noninflammatory AAA.

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Competition of interest: none.

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Table I. Age, sex, and prevalence of comorbidity in 31 patients with IAA and 62 control patients with AAA

	IAA		*Controls*		
	N	*%*	*N*	*%*	*Significance*
Age (y, median)	69.9		70.6		NS
Gender					
Male	25	81	48	77	NS
Female	6	19	14	23	NS
Comorbidity					
Coronary heart disease	11	35	20	32	NS
Chronic obstructive pulmonary disease	2	6	9	15	NS
Diabetes	2	6	3	4.8	NS
Renal failure	7	23	8	13	NS
Hypertension	8	26	17	27	NS

IAA, Inflammatory aortic aneurysm; *AAA,* abdominal aortic aneurysm; *NS,* not statistically significant.

MATERIAL AND METHODS

From 1983 to 1994, 520 patients were operated on because of AAA. All patient records were reviewed, and the cohort was reexamined in the outpatient clinic or by questionnaire to surviving subjects 5 to 16 years after the operation. Thus 100% follow-up was obtained. In 31 patients (6%) the operating surgeon diagnosed IAA. The macroscopic criteria for IAA used in our department include white glistening perianeurysmal fibrosis, thickened aneurysm wall, and dense adhesions of adjacent abdominal organs.[13] In 21 cases the diagnosis was confirmed at histologic examination with hematoxylin-eosin-saffran staining. Characteristic findings at microscopy were loss of smooth muscle cells and elastic tissue in the media, which in most cases was extensively replaced with fibrous tissue. The periaortic tissue exhibited granulation tissue with fibrosis and a lymphoplasmocytic inflammatory infiltrate, often with follicular aggregations of mature lymphoid cells. Granulomas were not observed.[7] Aneurysm wall thickening was recorded in all patients either intraoperatively, on the histologic specimen obtained during surgery, or on preoperative computed tomography scans.

Six patients (19.4%) with IAA were women; median patient age was 70 years (Table I). Twelve IAA (39%) were asymptomatic, 15 IAA (49%) were symptomatic without rupture, and 4 IAA (13%) were ruptured.

The study design was case-control within a cohort. The control group was matched for rupture, emergency or elective hospital admission, and date of operation. Control subjects were selected from a group of patients with noninflammatory AAA, and 2 control subjects were included for every patient with IAA, for a control group with 62 patients. Control subjects included the last patient operated on before and the first patient operated on after each patient with IAA. For patients with ruptured IAA, the last patient with ruptured non-IAA before and the first patient after served as controls. Review of medical records and follow-up were performed similarly in both groups. The diagnosis of autoimmune disease was made before surgery in all cases, and was verified by a rheumatologist from clinical investigation, serologic tests, and biopsy findings, when needed. We also compared the patients with IAA with the total group of 489 patients operated on to treat non-IAA during the study period. Because the control group was matched for rupture, and type of admission was related to occurrence of symptoms, we compared the incidence of symptoms with the total group of 341 patients with nonruptured AAA.

Table II. Prevalence of autoimmune disease in 31 patients with IAA and 62 control patients with noninflammatory AAA

	IAA	*Controls*	P
Autoimmune diseases	6 (19.3%)	0	.0017
Rheumatoid arthritis	3	—	
Systemic lupus erythematosus	2	—	
Giant cell arteritis	1	—	

IAA, Inflammatory aortic aneurysm; *AAA,* abdominal aortic aneurysm.

In-hospital resources were estimated from patient records. Length of stay, stay in the intensive care unit or intermediate care unit, operating time, anesthesia time (total time in the operating room), and need for assisted ventilation and blood transfusions were recorded. From preoperative investigations, concomitant diseases such as coronary heart disease (angina, previous myocardial infarction, percutaneous coronary intervention, or aortocoronary bypass grafting), hypertension treated medically, renal failure (creatinine concentration >140 μmol/L), chronic obstructive pulmonary disease, and diabetes were also noted.

The investigation was approved by the local ethics committee. Data were entered into the statistical database Medlog, with which analysis also was performed. For statistical analysis the nonparametric Wilcoxon rank sum test and χ^2 test, with appropriate corrections, were used. Observed differences with $P < .05$ were considered statistically significant.

RESULTS

Of the 31 patients with IAA, autoimmune disease was diagnosed in 6 before surgery. In contrast, no autoimmune

Table III. Symptoms and signs in patients with IAA compared with control subjects with noninflammatory AAA

	IAA (N = 30)		*Controls (N = 62)*		
	n	*%*	*n*	*%*	P
General symptoms	7	23	3	4.8	.02
Joint phenomena	2	6.7	0	0	NS
ESR (median) (mm/L)*	28.0		16.5		<.001
Hematocrit (median)*	0.38		0.43		.011
Aneurysm size (median) (mm)	65		60		NS
Duodenal involvement	19	61	—		—
Aortoduodenal fistula	1	3.0	—		—
Distal involvement†	9	27	—		—
Hydronephrosis	8	26	1	1.6	.0008
Right side	2		1		
Left side	3		0		
Bilateral	3		0		

IAA, Inflammatory aortic aneurysm; *AAA,* abdominal aortic aneurysm; *ESR,* erythrocyte sedimentation rate; *NS,* not significant.
*Patients and control subjects with ruptured aneurysms excluded.
†Inflammation extending onto common iliac arteries.

disease was found in the control subjects ($P = .0017$; Table II). Two patients (1 seropositive, 1 seronegative) had rheumatoid arthritis,[14] and 2 patients had SLE.[15] These diagnoses were in accordance with the criteria set forth by the American College of Rheumatology. Both patients with SLE also had antiphospholipid syndrome. One of these patients had low titer of antinuclear antibody, low titer of antideoxyribonucleoprotein, anti–Sjögren's syndrome A antibody, high titer of antiribonucleoprotein, and high titer of anti-Smith antibody, and medium titers of anti-ribonucleoprotein and anticardiolipin antibodies. This 39-year-old woman had an aneurysm with diameter of 65 mm. The other patient with SLE and antiphospholipid syndrome had an autoantibody profile consisting of positive antinuclear antibodies, medium titer of positive anticardiolipin antibodies, low titer of anti–Sjögren's syndrome A antibody, high titer of anti–Sjögren's syndrome B antibody, low titer of anti-Smith antibody. One patient had undifferentiated seronegative polyarthritis, which was diagnosed as rheumatoid arthritis. One patient had giant cell arteritis, documented by characteristic inflammatory lesions in the temporal artery. Microscopy of the biopsy specimen showed pronounced expansion of the internal lamina elastica, necrotic and hyalinized lamina media, infiltration of mononuclear leukocytes in all layers, and giant cells in the internal lamina elastica. American College of Rheumatology criteria for classification of giant cell arteritis were fulfilled.[16] In the IAA group, 1 patient with rheumatoid arthritis, 1 patient with SLE, and 1 patient with giant cell arteritis used oral corticosteroid therapy; no patients in the control group used such treatment.

In 3 of 489 patients (0.6%) with noninflammatory AAA autoimmune disease was diagnosed at operation. This incidence is significantly lower than in the patients with IAA ($P < .001$). One patient had sarcoidosis, 1 patient had SLE, and 1 patient had giant cell arteritis.

Patients with nonruptured IAA (n = 27) more often had abdominal pain, compared with patients with nonruptured AAA (n = 341)(51.9% vs 30.2%; $P = .04$). In turn, this seemed to cause a slight tendency toward urgent admission to hospital in the IAA group (48% vs 34%), but this difference did not reach statistical significance ($P = .20$). There was no significant difference in reports of back pain or tenderness at clinical examination in the two groups.

In the IAA group, median aortic wall thickness was 11.2 mm (range, 4.2-25 mm). There were no significant difference in maximal aneurysm diameter in the two groups, with median diameter of 60 and 65 mm, respectively. In patients with IAA, the duodenum was involved in 19 patients (61%) and the left renal vein in 5 patients (16%), and in 9 patients (29%) the inflammatory reaction extended beyond the aortic bifurcation. Eight patients (26%) in the IAA group had hydronephrosis from involvement of the urether, which was bilateral in 2 patients. Erythrocyte sedimentation rate was significantly higher in patients with IAA compared with control subjects (28 vs 16 mm; $P < .01$). General symptoms such as malaise and weight loss were more often observed in patients with IAA than in the control group (Table III).

There were no differences between groups with regard to incidence of preoperative coronary heart disease, hypertension, diabetes, or chronic obstructive pulmonary disease. Thus, with the exception of local fibrotic changes, there were no differences in preoperative risk factors in the two groups. Median operating time was significantly longer in the IAA group compared with the control group (203 vs 160 minutes; $P = .003$; Table IV). There was also a higher need for blood transfusion in the IAA group (median, 6 vs 3 units of saline adenine glucose mannitol blood; $P = .009$). However, there was no statistically significant difference in median postoperative hospital stay or time in the intensive care unit (108 vs 92 hours; $P = .209$). Neither was the need for assisted ventilation different (median, 0 hours). Thirty-day mortality among patients with IAA was 25% in those with ruptured aneurysm and 7.4% in patients

Table IV. Hospital resources used after operation in 31 patients with IAA compared with 62 control subjects with noninflammatory AAA

	IAA		*Controls*		
	Median	*Range*	*Median*	*Range*	P
Operating time (min)	205	110-320	160	65-381	.003
Anesthesia time (min)	300	185-455	274	125-535	.04
Postoperative hospital stay (h)	216	48-720	216	0-4416	NS
Intensive care/intermediate care unit stay (h)	108	36-542	92	5-4416	NS
Postoperative artificial ventilation (h)	0	0-144	0	0-3648	NS
Blood transfusion (median units SAG)	6		3		.009

IAA, Inflammatory aortic aneurysm; *AAA,* abdominal aortic aneurysm; *SAG,* saline adenine glucose mannitol blood; *NS,* not significant.

with nonruptured aneurysm, and there was no difference compared with the control subjects.

DISCUSSION

Walker et al[1] found no evidence of a systemic collagen disorder in their patients with IAA. However, other authors have proposed an autoimmune predisposition in such patients.[6] Prevalence of aortitis has been decribed in 10% of patients with ankylosing spondylitis,[17] and aortitis has also been found in a proportion of patients with rheumatoid arthritis.[9] Further, accelerated atherosclerosis, including plaque formation in the carotid arteries, and higher incidence of death due to cardiac disease have also been observed in this group.[18-20] Although AAA has been described in patients with various autoimmune diseases,[21] to our knowledge this is the first report to show a higher incidence of autoimmune disease in patients with IAA compared with matched control subjects with noninflammatory AAA. Evidence of a genetic predisposition for development of IAA exists. Thus a genetic risk determinant mapped to the HLA-DR molecule, and in particular to the HLA-DRB1 locus and the alleles B1*15 and B1*0404, suggests a role for genetic risk factors in IAA.[6,11] Of interest, substitution of a glutamine for a negatively charged aspartic acid at the entrance to pocket 4 significantly changes the binding of the pocket and therefore changes antigen selection. This suggests a critical role for antigen binding in the origin of the disease, and its distinct location on the HLA-DR molecule suggests disease specificity, compared with giant cell arteritis. HLA typing was not possible in our patients, but is done in prospective studies. Various environmental factors, eg, viruses, may have a role in the triggering mechanisms for development of inflammatory rheumatic disease, connective tissue diseases, and primary vasculitis. Tests for microbial antigens such as herpes simplex virus and cytomegalovirus[22-24] have not been performed. However, detection of these viruses in serum and in biopsy specimens of arterial wall can be done in forthcoming studies. Microscopy of biopsy specimens may be important to reveal cellular composition and deposits that reflect both extent and different types of immunologic activity in the vascular wall.[24]

Inasmuch as the question of increased incidence of autoimmune disease in IAA first was discussed after the study had been completed, there was no chance that the surgeons were biased and looked for autoimmune disease more diligently in patients with IAA. Furthermore, our criteria for IAA were the same during the entire study. In a case-control study, matching of control subjects is important. We decided to match for rupture and urgency of admission when we identified the control group. Selecting control subjects from the group of patients operated on directly before or after the index patients was done to provide comparable data, which compensated for any possible temporal differences in treatment policy. Primarily, we approached the data via a nested case-control design. A limitation of that design is not that we selected two control subjects per index case, but that the number of patients with the index condition, IAA, was restricted. It is recommended that the number of control subjects be increased,[25] as in our study, but not beyond 4:1. We choose 2:1 as a compromise, ie, the last eligible patient before and the first patient after each index case. However, to test our hypothesis further, we compared the occurrence of autoimmune diseases in the IAA group with that in the entire noninflammatory AAA group. A strength of the study was complete follow-up of patients throughout the entire period before introduction of endovascular procedures to treat AAA at our hospital.

Our hospital serves a well-defined geographic area. Autoimmune disease would have been recorded if the patient had received any treatment at a hospital in the region, because all patient records were thoroughly reviewed and 100% follow-up was obtained. We therefore find it unlikely that any autoimmune disease in the control group was missed.

The technical challenges represented by the inflammatory changes are reflected in the longer operating time and greater need for blood transfusion. This may be an argument in favor of endovascular therapy for IAA.[26-28] Endovascular repair is feasible in these cases,[29] but both regression and proliferation of the inflammatory changes[30] have been reported. Therefore this treatment method remains controversial. Thirty-day mortality of 7.4% in the patients with nonruptured IAA seems high, but includes two patients who underwent emergency surgery. One patient had acute ischemia of the left lower limb after arteriography. Closed compartment syndrome developed, and fasciotomy was required. Severe multiorgan failure developed, including renal failure, and the patient died on the tenth postoperative day. The other patient underwent emergency surgery because of pain, but there was no rupture. The immediate postoperative course was uneventful, but on the fifth postoperative day a large myocardial infarction occurred, which was verified at autopsy.

We investigated data for patients operated on from 1983 to 1994 because at that time all AAAs were treated with open surgery with a standardized technique that was the same for all operating surgeons. In February 1995 endovascular treatment was introduced in our hospital, and this technique has since been used in about 40% of cases. Thus patients who underwent open surgery since 1995 were selected.

Mitchinson[31] claimed that IAA, perianeurysmal fibrosis, and idiopathic retroperitoneal fibrosis are all a manifestation of the same process, and therefore proposed the common name periaortitis. This was later supported by Martina et al[32] in a series in which idiopathic retroperitoneal fibrosis seemed to be related to a high incidence of aortic atherosclerosis. Stella et al[33] also showed that degree of postoperative regression not unexpectedly is related to cell-fibrosis ratio, in which fibrosis preponderance is related to poor response with regard to regression of periaortic thickening after graft implantation. The results are not uniform, however,[34-38] and progression after open repair as well as endovascular repair have been reported.[31,35] Several reports of IAA and perianeurysmal fibrosis include a combination of both conditions,[1,37] and IAA, idiopathic retroperitoneal fibrosis, and perianeurysmal fibrosis are often clinically indistinguishable when complicated with uretheral involvement.

In conclusion, our study has demonstrated an association between IAA and autoimmune disease. This is in accordance with other reports that showed a genetic risk determinant mapped to the HLA molecule in these patients. The findings seem to contradict the theory that IAA is only an end stage of an inflammatory process present in all aortic aneurysms, and supports the theory that IAA is a separate entity. In this series there was longer operating time and higher need for blood transfusion after surgery to treat IAA, compared with operations to treat noninflammatory AAA. However, use of other hospital resources and early mortality were similar in both groups.

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CORRECTIONS

In: "Pixel distribution analysis of B-mode ultrasound scan images predicts histologic features of atherosclerotic carotid plaques" (Lal BK, Hobson RW II, Pappas PJ, Kubicka R, Hameed M, Chakhtura EY, et al. J Vasc Surg 2002; 35:1210-7).

The name *Ellie Y. Chakhtura* is spelled incorrectly. The correct spelling is *Elie Y. Chakhtoura*.

In: "Carotid artery stenting: analysis of data for 105 patients at high risk" (Hobson RW II, Lal BK, Chaktoura E, Goldstein J, Haser PB, Kubicka R, et al. J Vasc Surg 2003;37:1234-9).

The name *Ellie Y. Chaktoura* is spelled incorrectly. The correct spelling is *Elie Y. Chakhtoura*.

In: "Endothelial cell seeding fails to attenuate intimal thickening in balloon-injured rabbit arteries" (Conte MS, Choudry RP, Shirakowa M, Fallon JT, Birinyi LK. J Vasc Surg 1995;21:413-21).

The name *Choudry* is spelled incorrectly. The correct spelling is *Choudury*.

Paper III

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Emergency Non-ruptured Abdominal Aortic Aneurysm

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Objectives. *To investigate symptoms and early mortality (<30 days) following open surgery for emergency, symptomatic non-ruptured abdominal aortic aneurysm (AAA).*
Design. *Retrospective cohort study.*
Patients and methods. *During the period 1983–1994, 129 patients had an emergency admission, followed by surgery, for symptomatic non-ruptured AAA. Sixty-one received surgery within 24 h of admission and 68 received surgery more than 24 h after admission (median 135 h, inter-quartile range: 51–239 h). During the same period 239 patients had elective surgery for non-ruptured AAA. Early mortality (<30 days), symptoms and co-morbidities were recorded. Data were retrieved from the patient records.*
Results. *Mortality (30 days) was 18% in the 61 patients having surgery within 24 h of emergency admission for non-ruptured AAA. Mortality following either delayed surgery (semi-elective) after emergency admission or elective surgery was 4.2% (p=0.0002). Four out of 11 patients who died within 30 days following an acute operation had previously been declared unfit for elective surgery. One additional emergency patient had been found unfit for open surgery, but survived a delayed operation.*
Conclusion. *The high mortality rate of patients with non-ruptured, symptomatic AAA undergoing surgery within 24 h of admission appears to be influenced by several factors, including co-morbidities and the acute operation. We propose that the 30-day mortality for non-ruptured AAA should be reported in two categories: mortality rate for elective surgery and mortality for surgery performed within 24 h of emergency admission. The term 'emergency non-ruptured' is a suitable term for the latter group.*

Keywords: Non-ruptured AAA; Symptoms; Acute surgery; Mortality; Co-morbidity.

Introduction

Patients with infrarenal abdominal aortic aneurysms (AAA) are most often separated into three groups; elective or asymptomatic patients, patients with ruptured aneurysm and symptomatic or emergency patients without rupture.[1–6] The definition of the latter group is in many publications vague and the criteria for inclusion are in some cases based on symptoms only.[4,8] The group is then named 'symptomatic AAA'. Other definitions are related to the timing of surgery.[2,4] A clear definition of this group is important for a proper characterization and comparison of patients with non-ruptured AAA, since early mortality may vary according to inclusion criteria.

The dominant symptoms for emergency non-ruptured AAA are abdominal pain, back pain and a tender aneurysm on clinical examination.[2,9,4,10,11] A higher early mortality has been reported in the symptomatic or emergency group of patients compared to asymptomatic AAA.[2,5,6,11–16] The reason for this difference is unclear. Timing of surgery has also been controversial in symptomatic patients. Some surgeons have recommended operation without delay with the intention of preventing death from a possible rupture.[3,17–19] Others have argued for an approach where pre-operative assessment is performed and the operation carried out under more optimal conditions than is allowed by an emergency situation.[1,2,4,7,8,11,20–23]

Objectives

In this study, we separated patients with non-ruptured AAA according to different clinical criteria. The purpose was to investigate if symptoms, type of admission (elective versus emergency) and timing of

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surgery influenced early mortality (<30 days). Thus, we wanted to investigate whether it was possible to identify high-risk patients with non-ruptured symptomatic AAA.

Patients and Methods

During the period 1983–1994 altogether 520 patients were operated on for AAA at our institution. Patients from this period were selected for the study since endovascular treatment was started early in 1995. Of the 520 patients, 152 had ruptured aneurysm defined by the intra-operative finding of blood outside the aneurysm wall. In total 368 patients had non-ruptured AAA and 171 of them had symptoms considered to be related to their aneurysm (Fig. 1). Forty-three of these 171 had symptoms of relatively long duration and had been admitted electively. One hundred and twenty eight patients were admitted as emergencies, because of symptoms as was one further patient with evidence of rapid AAA expansion (20 mm in 10 months). In no other case did aneurysm size alone result in emergency admission. Sixty-one patients underwent surgery within 24 h of admission and the remaining 68 underwent delayed surgery (median 135 h, interquartile range: 51–239 h). Altogether 239 of the patients with non-ruptured aneurysms were admitted electively.

Emergency admission was defined as admission initiated without administrative or medical preparation when the patient was considered to need prompt diagnostic evaluation and possible treatment. For practical purposes, according to local practice, we defined emergency surgery as an operation performed within 24 h after emergency admission. Operation later than 24 h after an emergency admission was defined as 'semi-elective' because there was an

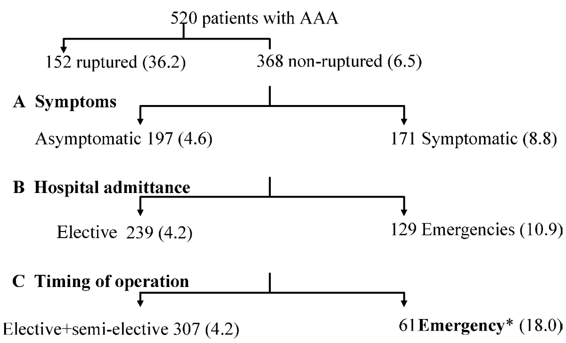

Fig. 1. Number of patients and early mortality (%) in subgroups of patients with non-ruptured AAA, according to 3 different classification criteria. *Emergency operation is defined as an operation within 24 h following an emergency admission.

opportunity for pre-operative evaluation and preparation similar to that in the elective situation.

We compared the three groups (emergency, semi-elective and elective) as well as asymptomatic versus symptomatic with respect to risk factors, comorbidity, symptoms and early mortality.

The nature and duration of symptoms were abstracted from medical records. Symptoms were identified when reported in the records. Abdominal pain, back pain and tenderness at clinical examination were defined as major symptoms. The feeling of pulsation and abdominal discomfort were regarded as minor symptoms. Duration of the dominant symptom was recorded in 7 categories ranging from '0–6 h' and up to '6 months'. Four patients with critical lower limb ischaemia and AAA and 2 with occlusion of the aneurysm, also were considered symptomatic. Aneurysm size, defined as the maximum cross-sectional diameter, was measured either by computed tomography scans, ultrasonography or intra-operatively. The majority of measurements were made by either CT-scan or ultrasonography. Although these modalities are not directly comparable, we used both as available. We also recorded whether the diagnosis of AAA was known prior to admission, whether the patient previously had been found unfit for elective surgery or had refused surgery. Aneurysms were reported as inflammatory if they had a grey–white appearance observed intra-operatively. Thickened aortic wall, peri-aneurysmal fibrosis and adhesions to adjacent abdominal organs were other characteristics of inflammatory aneurysm. The thickened wall was also observed on pre-operative CT-scans.[24,25]

Coronary heart disease (previous myocardial infarction, angina, aortocoronary bypass surgery or percutaneous coronary intervention), hypertension (treated medically), chronic obstructive pulmonary disease (COPD) and renal insufficiency (creatinine concentration >140 μmol/l) also were noted. Cardiac function was further categorized according to the classification of the New York Heart Association (NYHA) in 355 (96.4%) of the patients. The 30-day mortality following surgery was recorded.

Surviving patients have been followed either at the out-patient clinic or by contact with the primary physician. In addition, data on patient survival was collected from the Norwegian Registrar's Office of births and deaths, which is updated every 14 days. Statistical analyses were done in SPSS. Chi squared tests, with Yates correction and Wilcoxon rank sum tests were used. Observed differences with a p-value <0.05 were considered as statistically significant. The study received approval from the local ethics committee.

Results

Asymptomatic versus symptomatic patients

The 30-day mortality following surgery for non-ruptured AAA for 197 asymptomatic and 171 symptomatic patients was 4.6 and 8.8%, respectively, $p=0.16$ (Table 1). The age distribution in the two groups was similar but there was an indication that there were more women in the symptomatic group (24.0 versus 15.7%, $p=0.064$). Patients with symptoms had a larger median aneurysmal diameter (60 versus 50 mm, $p<0.001$). Inflammatory aneurysms were documented in 8.8% of the symptomatic patients and 6.1% of the asymptomatic patients. Symptomatic patients were more often classified as NYHA class 3 and 4 (11.0 versus 3.1%, $p=0.006$), with a tendency for coronary heart disease to be present more often in the symptomatic group (49.1 versus 39.3%). Asymptomatic patients reported intermittent claudication and hypertension more often than the symptomatic patients.

Elective versus emergency admission

The 239 patients admitted electively had a 30-day mortality of 4.2%, significantly lower than the 10.9% mortality in the 129 patients admitted as emergencies, $p=0.024$ (Table 2). Age was similar for the two groups, but there was an indication of an increased proportion of women in the emergency group (24.8 versus 16.7% in the elective group). Patients admitted as emergencies had significantly larger aneurysms (61.5 versus 50.0 mm, $p<0.001$). Emergency patients also had significantly more coronary heart disease, with a tendency for more patients having NYHA class 3 and 4 (10.7 versus 4.7%, $p=0.058$). In contrast, more elective patients were being treated for hypertension and complained of intermittent claudication. Inflammatory aneurysms were documented in more emergency admissions (10.1%) than elective admissions (5.9%, $p=0.203$). Some 43 (18%) of the elective patients had symptoms related to their AAA. However, most of the symptoms were minor and the duration of the dominant symptom was significantly longer than in patients admitted as emergencies. This subgroup of 43 patients had a 30-day operative mortality of 2.3%.

Emergency versus elective or semi-elective operation

When we combined the patients undergoing elective surgery with those undergoing surgery semi-electively, there was a total of 307 patients with a 30-day mortality of 4.2% compared with a mortality of 18% in the 61 patients with emergency surgery (Table 3). Age and gender was similar in the two groups. The aneurysm diameter was larger in the emergency group (64.5 versus 55 mm, $p=0.002$). Further, there were significantly more patients with NYHA class 3 and 4 (15.5 versus 5.1%, $p=0.009$) and a tendency towards more coronary heart disease in the emergency group (55.7 versus 41.5%, $p=0.06$). The presence of aneurysm was known prior to admission in 48 (37%) patients admitted as emergencies, but the diagnosis previously was unknown in the remainder. Inflammatory aneurysms were present in 8.2% of the patients undergoing emergency surgery versus 7.2% of those operated electively or semi-electively.

The duration of symptoms was significantly shorter in the emergency patients with a median of 3–7 days and most (93.4%) of these patients had major symptoms. In particular, 7/11 of the early deaths in this group occurred in patients where AAA had been diagnosed previously. Four patients who had previously been regarded unfit for elective operation

Table 1. Patient data, comorbidity and early mortality in asymptomatic and symptomatic patients with non-ruptured AAA

	Asymptomatic patients $N=197$% (n)	Symptomatic patients $N=171$% (n)	Sign. (p-value)
Gender (female)	15.7 (31)	24.0 (41)	0.064
Median age	69.7	68.7	0.382
Max.aneurysmal diameter (mm)	50 ($n=184$)	60 ($n=162$)	<0.001
Co-morbidity			
Coronary heart disease	39.3 (77)	49.1 (84)	0.074
NYHA class 3 and 4	3.1 (6)	11.0 (18)	0.006
COPD	9.7 (19)	13.5 (23)	0.344
Renal failure	12.7 (25)	11.1 (19)	0.761
Hypertension	35.7 (70)	26.2 (44)	0.066
Intermittent claudication	33.7 (66)	11.2 (19)	<0.0001
Mortality (<30 days)	4.6 (9)	8.8 (15)	0.156

COPD, chronic obstructive pulmonary disease

Table 2. Patient data, co-morbidity and early mortality in patients admitted electively and as emergencies for non-ruptured AAA

	Elective admission $N=239$% (n)	Emergency admission $N=129$% (n)	Sign. (p-value)
Gender (female)	16.7 (40)	24.8 (32)	0.085
Median age	69.0	69.7	0.589
Max. aneurysmal diameter (mm)	50.0 (222)	61.5 (124)	<0.001
Co-morbidity			
Coronary heart disease	39.9 (95)	51.2 (66)	<0.05
NYHA class 3 and 4	4.7 (11)	10.7 (13)	0.058
COPD	11.0 (26)	12.4 (16)	0.811
Renal failure	12.1 (29)	11.6 (15)	0.980
Hypertension	35.3 (84)	23.8 (30)	0.033
Intermittent claudication	30.4 (72)	10.1 (13)	<0.0001
Symptoms			
Major symptoms	9.6 (23)	89.1 (115)	<0.001
Only minor symptoms	8.4 (20)	6.2 (8)	0.676
Critical lower limb ischemia	0.4 (1)	2.3 (3)	
Acute AAA occlusion	0	1.6 (2)	–
Duration of symptoms	>6 months	1–2 weeks	<0.001
Mortality	4.2 (10)	10.9 (14)	0.024

COPD, chronic obstructive pulmonary disease. Only 43 electively admitted patients reported symptoms. The mortality of this sub-group was 2.3%.

due to cardiac failure, decreased pulmonary function and malignancy, died within 30 days after emergency surgery. Only one patient (who survived surgery) had been found unfit for open surgery in the semi-elective group. In patients with a previous diagnosis of AAA who underwent emergency surgery, the 30-day mortality was 35%, compared with a mortality of 10% for those undergoing emergency surgery without previous diagnosis of AAA.

The causes of death of all patients are given in Table 4. Cardiac disease and multi-organ failure were the most common causes of death.

Discussion

Mortality and size of groups

This study shows that operative mortality is highest for symptomatic patients undergoing emergency surgery (within 24 h) for non-ruptured AAA and that these patients have larger aneurysms and poorer NYHA classifications than other patients undergoing surgery for non-ruptured AAA. The presence of inflammatory AAA appeared less important. The

Table 3. Patient data, co-morbidity and early mortality in patients operated electively and semi-electively compared to those operated as emergencies for non-ruptured AAA

	Elective/semi-elective operation $N=307$% (n)	Emergency operation $N=61$% (n)	Sign. (p-value)
Gender (female)	18.2 (56)	26.2 (16)	0.208
Median age	69.1	69.9	NS
Max. aneurysmal diameter (mm)	55 ($n=288$)	64.5 ($n=58$)	0.002
Co-morbidity			
Coronary heart disease	41.5 (127)	55.7 (34)	0.057
NYHA class 3 and 4	5.1 (15)	15.5 (9)	0.009
COPD	10.4 (32)	16.4 (10)	0.271
Renal failure	12.4 (38)	9.8 (6)	0.732
Hypertension	34.3 (105)	15.5 (9)	0.008
Intemittent claudication	26.2 (80)	8.2 (5)	0.004
Symptoms			
Major symptoms	26.4 (81)	93.4 (57)	<0.001
Only minor symptoms	8.5 (26)	3.3 (2)	0.281
Critical lower limb ischemia	0.3 (1)	2.3 (3)	–
Acute AAA occlusion	0.3 (1)	1.6 (1)	–
Duration of symptoms	1–6 months	3–7 days	<0.001
Mortality	4.2 (13)	18.0 (11)	0.0002

COPD, chronic obstructive pulmonary disease.

Table 4. Causes of death according to urgency of operation in patients operated on for non-ruptured AAA

	Elective operation $N=239$	Semi-elective operation $N=68$	Emergency operation $N=61$	Total $N=368$
Myocardial infarction	4	2	2	8
Multiorgan failure	1	1	3	5
Cardiac failure	1		2	3
Haemorrhage	2		1	3
Intestinal ischaemia	1		1	2
Pulmonary insufficiency	1			1
Renal failure			1	1
Unknown			1	1
Total	10	3	11	24

rationale for dividing patients with non-ruptured AAA into two groups was that elective patients with asymptomatic AAA have a different course and mortality than the corresponding group of patients with non-ruptured symptomatic AAA admitted as emergencies. In the latter group the indication for surgery is not only prophylactic, but to treat a suspected or impending rupture or a concomitant life-threatening condition such as critical lower limb ischaemia. Consequently, the emergency group will contain high-risk patients who might have been found unfit for elective surgery. However, this is unlikely to be the only reason underlying the high operative mortality in the patients undergoing emergency surgery.

Timing of surgery

In various reports the definition of acute, emergency and urgent surgery varies strongly.[8] The time limit for acute surgery has ranged in different reports from within 6 h after admission to several days.[4,13,20] In our institution, patients with non-ruptured aneurysm admitted as emergencies represented 35% of the total cohort of AAA patients. Among 368 patients with non-ruptured AAA, there were11 early deaths among the 61 patients undergoing emergency surgery, accounting for almost half (46%) of the total 30-day mortality. Therefore this is an important group to target to reduce operative mortality for the total group of patients with non-ruptured AAA.

High-risk patients, including those previously unfit for elective surgery do not appear to benefit from emergency surgery. Four such patients undergoing emergency operations died within 30 days, but another previously unfit patient survived a semi-elective operation. Emergency surgery may be an independent risk factor for mortality, for even those with previously undiagnosed AAA, the mortality following emergency surgery was 10%. Postponement of the operation for more than 24 h after an emergency admission resulted in the same 30-day mortality as for patients with asymptomatic AAA undergoing elective surgery. There were no cases of rupture following the decision to postpone surgery and allow pre-operative assessment, following emergency admission for symptomatic AAA. Others have reported similar findings.[26,27] It has also previously been stated that emergency operation is associated with a higher mortality[7,20,28] and that any policy change to a more immediate operation could lead to an increased mortality in this specific group of patients with symptomatic non-ruptured AAA.[2]

In haemodynamically stable patients, where clinical examination indicates that rupture is unlikely, a computed tomography scan is indicated to rule out the possibility of contained rupture. Thereafter, one option is to transfer the patient to an intermediate care unit for monitoring of blood pressure and organ function, giving time for optimising organ function.[29,30] If beta-blockers have not been prescribed previously, these should be administered prior to surgery and maintained throughout the hospital stay. In current practice there may be and indication for endovascular treatment in the high-risk patients. Finally, the patient should be operated during the day, by an experienced surgical and anaesthetic team and appropriate intensive care facilities should be available.[28]

Symptoms

In this series 18% of the elective patients reported symptoms from their AAA, while all but one of the patients admitted as emergencies had symptoms related to their AAA. In Estes' series from 1950 of 102 non-operated AAA, only 30% were asymptomatic.[29] To our knowledge there are no reports describing the natural history of patients with symptomatic aneurysm or whether the symptoms predict rupture. Major symptoms like pain and tenderness were more common among emergency patients, while the feeling of pulsation in the abdomen was the most often reported symptom in the elective group. We observed a significantly shorter duration of symptoms in patients admitted as emergencies compared to the elective group and also in those operated within 24 h of admission. Our study did not evaluate the intensity of symptoms since this would have been difficult to do retrospectively.

Symptoms in patients with AAA can be caused by other conditions, previously described as pseudo-rupture syndrome.[17] For these patients, it is assumed that an emergency operation can be beneficial whenever the symptoms are caused by a life-threatening secondary condition.[19] In other cases an emergency operation can be related to an increased risk, for instance when the symptoms are due to myocardial infarction. We could not identify a specific symptom that was related to early mortality, but a rapid change in symptoms might lead to emergency admission to hospital and emergency surgery and thereby contribute to a higher mortality.

Patient risk factors

Symptomatic patients and patients admitted as emergencies had a higher prevalence of cardiac disease and more of them belonged to NYHA class 3 and 4 than the corresponding non-symptomatic elective patients. The key risk factors underlying mortality risk following elective surgery were not identified clearly in this study. Assessing risk factors properly demands a thorough clinical evaluation and testing of organ function, which could be difficult to carry out in symptomatic patients.[5] In a retrospective study like this there are difficulties associated with collecting necessary information from the patient's records. Thus, data for NYHA classification were missing in 13 (3.5%) of the patients. Surprisingly more cases of hypertension and intermittent claudication were reported among the patients undergoing elective surgery for asymptomatic AAA. One explanation could be that the medical records were more complete for elective admissions.[30] Another factor might be that symptoms from the aneurysm could shift the focus away from concomitant vascular disorders. In the symptomatic patients, with their increased evidence of cardiac disease, symptoms of lower limb arterial obstruction could be masked.

Nomenclature and definition

Interpretation of this study must be done with caution because of the retrospective design and the relatively small number of patients. Prospective randomised trials would, however, be difficult to perform for evaluation of matters concerning clinical judgement and subjective symptoms like pain. The study has indicated that neither symptoms nor emergency admission alone are suited as classification criteria to identify high-risk patients with non-ruptured AAA. In our opinion this group of non-ruptured AAA should be named 'Emergency non-ruptured' instead of symptomatic AAA and defined by an emergency admission with surgery in the following 24 h. An important implication of this definition is that excessive mortality due to other factors than high-risk patients easier can be detected in a narrow 'emergency group' than in a wider 'symptomatic group', which may include elective as well as semi-elective patients. To be able to compare results from different vascular units, reporting must be based on reproducible criteria. As a consequence, use of terms like impending rupture, symptomatic, tender AAA and urgent AAA should be abandoned unless defined properly.

Conclusion

In patients with emergency non-ruptured AAA, emergency surgery (within 24 h) together with increased co-morbidity appeared to be risk factors for early mortality. If rupture can be ruled out, it seems likely that these patients, when admitted as emergencies, have a better prognosis if a period of time is used for pre-operative assessment and optimisation of organ function before semi-elective surgery is undertaken. We suggest that 'emergency non-ruptured' is better suited as a term for patients who are admitted as emergencies and operated on within 24 h for non-ruptured AAA.

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Paper IV

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Elective Open Operation for Abdominal Aortic Aneurysm in Octogenarians—Survival Analysis of 105 Patients

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Objectives. *To study early mortality and long-term survival of patients more than 80 years of age having elective open repair for abdominal aortic aneurysm (AAA).*
Design. *Retrospective multicenter cohort study.*
Material. *One hundred and five patients, 23 women and 82 men, with a median age of 82 years, operated at three Norwegian hospitals during the period 1983–2002.*
Method. *Survival analyses were based on data from medical records and the Norwegian Registrar's Office of Births and Deaths. Expected survival was based on mortality rates of the general population, matched by age, sex, and calendar period. Relative survival was calculated as the ratio between the observed and the expected survival.*
Results. *During the study period there has been a 10 fold increase in octogenarians treated with open operation for AAA. Early mortality (30-day) for the whole group of patients was 10.5% (95% confidence interval (95% CI) 5.3–18.0), and similar for both genders. The 5-year survival rate was 47% (95% CI 35.9–57.4), and not significantly different from that of a matched group in the general population. Patients aged 84 years or more had a median survival time of 35 months (95% CI 18.5–51.6).*
Conclusion. *The number of AAA operations in octogenarians has increased considerably during 20 years. Octogenarians operated electively for AAA has higher 30-day mortality as compared to younger patients. Their long-term survival appears similar to a matched control group. The benefit of surgery must be carefully considered against the perioperative risk, especially for the oldest octogenarians.*

Keywords: Abdominal aortic aneurysm; Elective surgery; Octogenarians; Survival.

Abdominal aortic aneurysm (AAA) is an age-related disease accounting for 1–2% of all deaths in men.[1] The overall life expectancy of the population is rising and more elderly patients are likely to present with AAA in the future. At present, surgery is the only treatment option for aortic aneurysms, but the risk of operation is not negligible and it increases with age. Most series published on this topic have included a limited number of patients from a single institution.[2] However, one register-based study with more than 200 male octogenarians operated electively has been reported previously.[3]

The objective of this study was to assess the early mortality (30-day), complication rate and long-term survival of patients aged 80 years or more who had been treated electively with open operation for AAA. Furthermore, we wanted to compare the long-term survival of the study group with an age and sex adjusted normal population to estimate relative survival.

Material and Method

Patients

During the period 1983–2002, 1408 consecutive patients treated with open elective operation for AAA were retrieved from medical and administrative registers at two university hospitals and one county hospital in Norway. Of these patients, 105 patients were octogenarians and enrolled for this study. Thirty-one octogenarians of 188 patients treated electively with endovascular aortic aneurysm repair (EVAR) in

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the same period were not included. Altogether 23 women and 82 men were included. The median age of the patients was 82 years (inter quartile range (IQR) 80.7–83.9), and 24 patients were more than 84 years of age. Although the age distribution was similar between genders, men tended to be slightly older than the women (82.2 versus 80.8). The median size of the aneurysms was 65 mm (IQR 58–80). There were no significant differences in aneurysmal size between subgroups of patients, but women seemed to have slightly larger aneurysms than men (68 versus 65 mm).

Data on risk factors such as coronary heart disease (angina pectoris, myocardial infarction or treatment with aorto-coronary bypass/percutanous coronary intervention) congestive heart disease (CHD), renal failure (serum creatinine concentration >140 μmol/l), chronic obstructive pulmonary disease (COPD) and postoperative complications were extracted from the medical record of each patient. Follow-up was based on the Norwegian Registrar's Office of Births and Deaths, which is updated every 14 days. Mean follow-up for the survival analysis was 42.4 months with a median of 34.3 months, and a 100% follow-up was obtained.

Statistics

To compare median values we used Mann–Witney *U* test, and proportions were compared with the Pearson's X^2 test. Crude survival was calculated using the product limit method, and illustrated as Kaplan–Meier curves. Relative survival was calculated as the ratio between observed and expected survival. Expected survival was estimated from mortality rates issued by the Norwegian Bureau of Statistics, and matched for age, sex, and calendar period using the Ederer I method.[4] Data were handled in SPSS® 11.0, but imported to Stata® 8.0 for survival analysis.

Results

The frequency of elective AAA operations increased during the study period from five operations in the three hospitals during the 5-year period 1983–1987, to 50 operations in the time span from 1998 to 2002 (Fig. 1). Dominating co-morbidities were cardiovascular disease and renal failure (Table 1). Risk factor distribution was similar for men and women, except for renal failure, which was more frequent among men (21 versus 0%, $p=0.02$).

The early mortality (30 day) for the total group of patients was 11% (CI, 5.3–18.0), and was similar among men and women; 11 and 9%, respectively (Table 2). The 24 patients aged 84 years or more had an early mortality of 17% compared to 9% for the patients aged 80–83 years ($p=0.26$). Early mortality did not change during the study period. During the years 1983–1994, 35 patients were operated with four early deaths (11%), while seven out of 70 patients (10%) died within 30 days after surgery during the period 1995–2002. For comparison, 30-day mortality after elective operation in patients less than 80 years of age was 4.2% in the two university hospitals in the same period. Data from the county hospital were not available.

Similar results were obtained in multivariate Cox' regression analyses in which we adjusted for pre-operative risk factors (CHD, COPD, diabetes, kidney insufficiency) as well as age, gender and calendar period of operation.

Twelve patients were reoperated on for surgical complications; nine due to haemorrhage, two with intestinal necrosis and one with critical lower limb ischaemia. The most frequent medical complications were myocardial infarction (MI) and renal failure (Table 2). Of the 11 deaths within 30-days, eight were due to cardiac complications. Only three of these patients had known heart disease preoperatively. Five of the 11 patients with a postoperative MI died within 30 days of the operation. Of the 17 patients with preoperatively registered renal failure, eight had normal serum creatinine values in the early post-operative phase, whereas two of these patients needed temporary postoperative dialysis. Fourteen patients (13%) needed postoperative respiratory support for more than 1 day. The median postoperative hospital stay was 9 days.

Mean follow-up for survival analysis was 42.4 months with a median of 34.3 months. Overall 5-year crude survival was 47% (Fig. 2, Table 3). The expected 5-year survival based on national figures was 55%, giving a relative survival of 86%. The observed differences in survival between men and women (log rank test, p-value$=0.2$), and between the younger and oldest patients in the cohort (log rank test $p=0.13$) were not statistically significant. The 5-year survival among men (42%) (Fig. 3) seemed lower than among women (68%), (Fig. 4, Table 3). For patients aged 84 years or more, the 5-year survival was 38% compared to 50% in patients aged 80–83 years. The 5-year relative survival was somewhat lower for men (81%) than among women (101%), while the relative survival for patients aged 80–83 years and for patients aged 84 years or more, were similar (86 and 82%, respectively). Overall median survival was 52 months, being slightly longer for women (63 months), than for men (42 months), and somewhat longer for patients aged 80–83

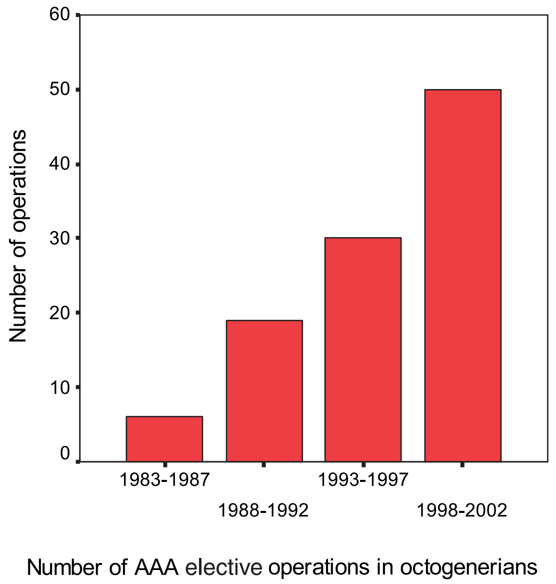


Fig. 1. The number of AAA operations in octogenarians from three Norwegian hospitals in 5-year intervals during the period 1983–2002.

years at operation (54 months) compared to patients aged 84 years or more (35 months).

Discussion

Early mortality and complications

An early mortality of 11% might be regarded as high for a prophylactic procedure, but the figure is in accordance with the mortality for high-risk patients in a recent review article.[5] Although the 30-day mortality in some centers of excellence is less than 2%, most centres report perioperative mortality exceeding 5% for all patients operated electively for AAA.[5,6] For octogenarians, early mortality was 8% in a register-based report, although the numbers vary in different publications from single hospitals.[2,3,7] Our multicenter study supports the observation that octogenarians are at higher risk than younger patients of early post-operative death. Due to the small size of the present study, a formal analysis of the causes of death would not be meaningful, and was thus abandoned. But as expected, cardiac disease was the dominating cause.

Table 1. Co-morbidities in 105 consecutive octogenarians operated electively for AAA in three Norwegian hospitals 1983–2002

	N	Percent
Co-morbidity		
Hypertension	38	36.2
Coronary heart disease	31	29.5
Arrhythmia	16	15.2
Renal failure	17	15.2
Valvular heart disease	9	8.6
COPD	7	6.7
Cerebrovascular event	7	6.7
Clinical CHD	5	4.8
Diabetes	5	4.8

CHD, congestive heart disease; COPD, chronic obstructive pulmonary disease.

Table 2. Postoperative results following 105 consecutive elective open operations of AAA in octogenarians

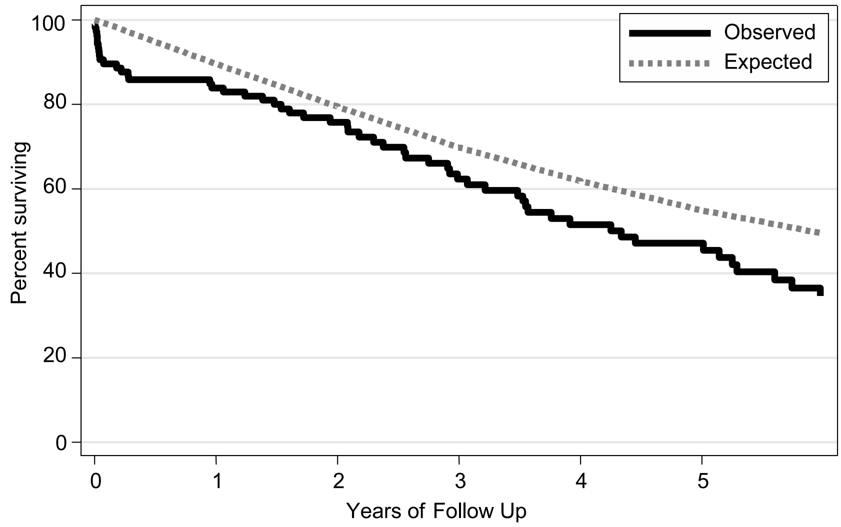
	N	Percent
Complications		
Mortality 30 day (all)	11	10.5
Women	2	8.7
Men	9	11.0
Reoperations	12	11.4
Myocardial infarction	11	10.5
Postoperativ CHD	9	8.6
Renal failure*	10	11.4
Dialysis†	2†	1.9
Wound infection	0	–
Amputation	0	–
Resources		
Median postoperative hospital stay (d, IQR)	9 (7.2–14.0)	–
Ventilatory support >1 day	14	13.3

IQR, inter quartile range; CHD, congestive heart disease.
* Patients without preoperative renal failure.
† Both patients had preoperative renal failure.

The complication rate in this series also seems fair, although 11% reoperations is rather high. Nine reoperations due to haemorrhage may indicate a potential for improved surgical technique, although all the procedures were performed in vascular units where trained vascular consultants usually attend all operations. Myocardial infarction (MI) was a dominating complication, and 50% of the patients with postoperative MI had no previous history of coronary heart disease. Guidelines have been published on preoperative assessment before major surgery, but no randomised clinical trials (RCT) on the matter have to our knowledge been reported yet.[8] In addition to history, physical examination and ECG, walking together with the patient up stairs is an inexpensive and efficient test of functional capacity, which can easily be done to select patients for further cardiac evaluation.[9]

Eight out of 17 patients with preoperative renal failure according to our definition had a postoperative normalisation of serum creatinin values. This indicates that our preoperative cut-off value for serum creatinin concentration >140 μmol/l may have been too low for identifying patients at elevated risk. Treatment of preoperative dehydration is the most likely explanation for the postoperative improvement in renal function observed in some of these patients.

Patients with AAA often have generalised



Patients at risk: 88 68 49 36 28

Fig. 2. Survival probability of the total group of 105 octogenarians (—) operated electively for AAA compared with a matched population (– – –).

atherosclerotic disease, which is a well-known risk factor for early postoperative complications and death. Still, atherosclerosis is widely distributed among octogenarians in general, and patients selected for elective operation may also have been healthier than the general population in the same age groups apart from the AAA. A median postoperative stay of 9 days is in accordance with other publications on patients aged 80 years or more.[10]

Gender

The UK small aneurysm trial has indicated that the risk of rupture in women is three times higher compared to men with similar aneurysm size.[11] Thus, a 60 mm aneurysm in a man corresponds roughly to a 52 mm aneurysm in a woman because women are smaller than men.[12] In this study, we did not find any significant differences in early mortality or survival between the genders, probably due to the small number of patients, but the women showed a tendency of better long-term survival after operation. Surprisingly the women also had slightly larger aneurysms than the men, which actually should imply a greater risk of rupture.[5] One explanation could be that more elderly women than men have been turned down for elective surgery during this period. It has previously been demonstrated that women are also less likely to be selected for open repair of ruptured aneurysm.[13] The comparison between men and women may, therefore, have been biased if healthier women than men were selected for operation. The possibility of a higher threshold for surgery in women could also be supported by the finding of a significantly higher prevalence of renal failure in the male population of the cohort.

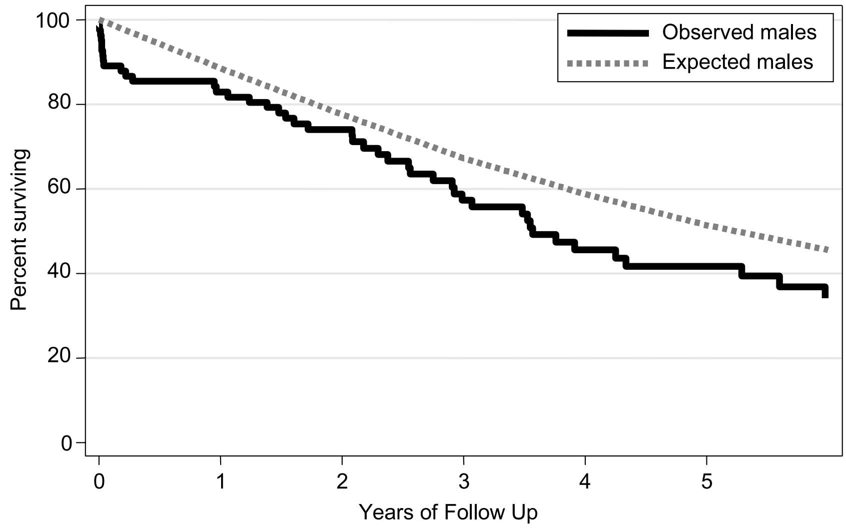
Number of operations

A 10 fold increase in admissions of octogenarians in

Table 3. Crude and relative 1- and 5-years survival stratified by sex and age in octogenarians operated electively for AAA in three Norwegian hospitals 1983–2002

Variable	*N*	1-year survival (%)			5-year survival (%)		
		Observed survival	Relative survival*	95% CI	Observed survival	Relative survival*	95% CI
All	105	83.8	94	84–100	47.1	86	65–105
Women	23	87.0	93	70–103	68.2	101	61–126
Men	82	82.9	94	82–101	41.7	81	58–104
80–83	81	85.2	94	83–101	49.7	86	64–107
>84	24	79.2	92	66–105	37.7	82	37–127

* Relative survival was calculated as the ratio between observed and expected survival. Expected survival was estimated based on mortality rates from the general population matched by age, sex, and calendar time using the Ederer I method.



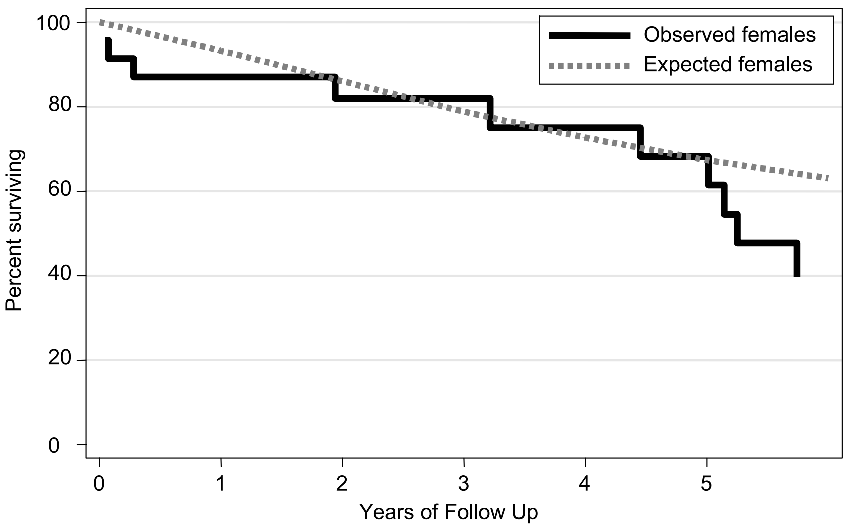
Patients
at risk: 68 53 37 25 18

Fig. 3. Survival probability of 82 male octogenarians operated electively for AAA (—) compared with a matched population (– – –).

surgical departments has also been documented by others.[14] They also found an increase in operations on octogenarians from 1.1 to 5.1% relative to all operations performed in one hospital during the period 1973–1989. This may not only reflect a growing population of octogenarians, but also a greater expectation of a successful outcome of surgery in this group of patients. Improved postoperative care, anaesthesia and surgical methods might have promoted this development. Since the technique of EVAR was established in Norway in 1995, several octogenarians have been recommended for EVAR. If the patients treated with EVAR had been included in this study, the increase of octogenarians treated for AAA would have been even larger during recent years.

Benefit from operation

The patients selected for the present study were operated on prophylactically for an asymptomatic



Patients
at risk: 20 15 12 11 10

Fig. 4. Survival probability of 23 female octogenarians operated electively for AAA (—) compared with a matched population (– – –).

condition, not immediately life threatening, and the relative survival seems fair. Ideally a study on benefit from treatment should be performed as a RCT, but it would probably be both ethically and medically difficult for many surgeons not to treat patients with large AAA's. In two RCT's on small aneurysms, >60% of the patients in the surveillance groups underwent operation during the study period.[15,16] Another problem is the weak documentation on the natural history of expansion and rupture of large aneurysms. In a recent study rupture occurred in 50 patients who had previously been turned down for elective surgery.[12] Among them 22 patients were operated on when rupture took place and the 30-day mortality after operation was 50%. The average rupture rate for men and women with AAA >60 mm was 19% per year. The contribution of aneurysm repair to life prolongation in octogenarians with limited life expectancy is, therefore, questionable. A recent review also emphasized that the number of years lost is greater for a death occurring during elective AAA repair than for a death resulting from late rupture, e.g. at 86 years of age.[17] Another study showed that 50% of patients unfit for elective operation of aneurysms with a diameter of more than 70 mm had died from other causes than rupture within 16 months.[18] Studies have also been performed to assess gained lifetime relative to the costs of operation for ruptured AAA in octogenarians,[19] but we have not found similar studies on benefit from elective operation. In elderly patients it is, therefore, difficult to balance the benefit of an operation against the risk of mortality and complications following surgery.

One study reported a similar quality of life (QoL) in patients surviving operation for AAA and in the normal population, but a period of 3–6 months was necessary to recover from operation.[20] In contrast, another study showed that 36% of operated patients experienced lack of recovery to preoperative status after an open AAA operation, and 18% would not undergo open AAA repair again after having experienced the recovery process.[21]

The surgeon should, therefore, in addition to the possibility of prolonging the patient's life, consider the possibility of worsening the physical and mental status of the patient after the operation. Knowing the risk of early death and the problems of postoperative recovery, information rather than persuasion seems most appropriate when deciding whether to operate on patients over 80 years of age with AAA or not. Results from studies on treatment with EVAR seem to make this an attractive alternative when treating elderly patients with limited life expectancy, provided they are anatomically suited.[22–26] Although the potential for late complications has been higher after EVAR than after open repair, this method seems to have a lower mortality (30 day) and a lower risk of serious morbidity and impaired physical functioning.[27–29]

Conclusion

The risk of early death after elective open AAA repair is higher for octogenarians than reported for younger patients. Long-term survival appears similar to that of a population matched for age and gender. However, the benefit of operation should always be thoroughly evaluated, especially among the older octogenarians. When suitable, EVAR might be considered in elderly, high-risk patients.

Acknowledgements

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Paper V

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Quality of Data Reported on Abdominal Aortic Aneurysm Repair—A Comparison between a National Vascular and a National Administrative Registry

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Objective. *To study consistency of data and completeness of reporting in a national vascular registry, NorKar, and a national administrative registry, The Norwegian patient register (NPR).*
Design. *Comparative registry-based national study supplemented with a comprehensive control of patients registered in one major hospital.*
Material. *All patients registered with a procedure-code for treatment of AAA in NorKar or NPR during 2001 or 2002, were included.*
Method. *We compared the reporting of procedure-codes, diagnosis-codes and in-hospital deaths after treatment for abdominal aortic aneurysm (AAA) in the two registries to evaluate completeness. Consistency between procedure-codes and diagnoses were evaluated within both registries. Completeness of reporting to one NorKar Local Registry was investigated in more detail in one of the hospitals.*
Results. *Compared with the NPR numbers, NorKar contained 69% of the patients treated for AAA in Norway, while completeness for NorKar member hospitals was 84%. The detailed investigation in one of the hospitals showed a completeness of 91% and a false inclusion of 5.3% of all cases treated for AAA. The consistency between procedure-codes and diagnosis-codes was 93% in both registries. We found evidence of substantial underreporting of in-hospital deaths to NorKar in several hospitals. Overall reporting of early deaths to NorKar relative to completeness of reported cases was estimated to 72%.*
Conclusion. *There is an underreporting of patients with AAA to NorKar according to the NPR numbers and a need for better control of procedure-diagnosis consistency in both registries. There seems to be a substantial underreporting of early deaths to NorKar. Introduction of unique patient-identifiable data could improve the quality of both registries by making matching of data possible.*

Keywords: Abdominal aortic aneurysm; Vascular registries; Coding; Completeness; Consistency.

Introduction

Establishing registries for various medical conditions has become more common during recent years. In 2002, Norway had more than 60 official medical registries of which 50% received financial support from the authorities.[1] As registry based studies are getting more common, there is need for validation of the registries forming the basis for these investigations. So far there have been few publications on quality control on different vascular registries, and published studies have mainly focused on reproducibility of the reported data by recoding trials of random cases.[2–4] Analyses on completeness have to our knowledge only been performed for single hospitals and have ranged from 51 to 100%, with a considerable variation between the hospitals.[2] Reproducibility of entered data has in audits ranged from 76 to 100%[3–5] depending on the accuracy of the variables. To our knowledge no comparison of vascular surgical procedures in different national registries has been reported so far.

The objective of this project was to study quality of data on treatment of abdominal aortic aneurysm (AAA) in a national vascular registry compared to a national administrative registry, with focus on consistency between procedure-codes and diagnosis, completeness of reporting of procedures and in-hospital deaths. In addition, we wanted to evaluate

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the completeness of one local vascular database (NorKar Local Registry) by matching relevant data on AAA treatment available in various registries in one major hospital.

Material and Methods

The Norwegian vascular registry (NorKar)

The national registry of the Norwegian society for vascular surgery was established in 1995 and includes different arterial procedures. In 2001, 17 out of 23 departments of vascular surgery were reporting to the registry. NorKar is based on local databases (NorKar Local Registries) with patient-identifiable data in member-hospitals, which reports all cases anonymously to the central registry on a regular basis. The registry contains diagnosis-codes (limited to a maximum of three), procedure-codes (limited to a maximum of six) for each treatment and variables on risk factors, symptomatology, indication for surgery, surgeon's position, complications and vascular graft patency.

Norwegian patient registry (NPR)

The Norwegian patient registry, established in 1997, is an independent registry of all patient treatments in the public healthcare of Norway, and is owned by the Norwegian ministry of health. This administrative registry contains all patient consultations at the outpatient clinics as well as all hospital stays. The hospitals are getting compensation from the authorities on the basis of the volume of reported diagnoses and procedure-codes according to a DRG (Diagnosis Related Groups) -based system, and NPR consists of the reported data. In 2001, 60% of the hospitals' income was based on this system. Thus, there is a strong incentive for the hospitals to report their activity completely. Reporting to the administrative registry is also compulsory to formally discharge a patient from hospital. The registry contains diagnosis-codes, procedure-codes and several administrative variables like waiting time until admission, status at discharge from hospital (alive/dead) and the need for further care.

Coding-systems

Both registries use International Codes of Diseases ICD-10 for recording of diagnoses.[6] For coding of procedures, both registries use the Norwegian translation of the NOMESCO (Nordic Medical Statistics Committee) classification of surgical procedures (NCSP).[7] NCSP-E is the original English version of the coding-system, which was first published in 1996.[8] NCSP codes were designed to describe in order; organ system (first letter), functional anatomical region (second letter) and general surgical method (third letter). The last two numbers describe in order the specific procedure in the category by surgical technique and exact anatomical localisation. NCSP has been implemented in all Scandinavian countries with a translated version for each country. Both the vascular and the administrative registry contain date of admission, procedure and discharge from hospital, which also makes calculation of in hospital mortality possible. Thirty-day mortality is not available in any of the registries. The forms for each hospital stay are filled in by the residents and consultants of the vascular unit, the coding and other data from the forms are then entered to a computer by secretaries. But while data from the vascular registry is not used for administrative purposes, NPR data will be checked by the administrative staff of the hospital, and correction may be performed before reporting to the central authorities.

A search was done in the Norwegian patient registry and the Norwegian vascular registry for patients with the NCSP procedure-codes of open, endovascular and endoscopic repair of AAA (PDG10, PDG 21, PDG 22, PDG 23, PDG24, PDQ10, PDQ10+PDQ30 and PDS 10) for the years 2001 and 2002. A similar search was done in both registries. The investigation is based on number of operations, with the consequence that there can be more than one registration per patient. Some of the relevant procedure-codes will also have been used for treatment of other conditions than AAA (I71.3-4, 8–9). In the present study, we defined procedure-diagnosis-consistency as a NCSP procedure-code combined with an ICD-10 diagnosis-code of a relevant indication for the procedure performed. We, therefore, developed a procedure-diagnosis-consistency table (Tables 1A and 1B) for all possible consistent combinations. Cases with a consistent combination for other indications than treatment for AAA, e.g. the implantation of bifurcated vascular graft (PDG20-24) combined with iliac artery aneurysm (I72.3), and implantation of endovascular prosthesis (PDQ10) together with aortic atherosclerosis (I70.0), were excluded from the investigation when no diagnosis of AAA was present. All the other cases with one or more of the defined procedure-codes were included, also when there was no ICD-10-code for AAA among the diagnosis-codes.

At the national level both registries are anonymous, but the administrative registry has a unique

Table 1A. Consistent combinations of NCSP procedure-codes and ICD-10 diagnosis codes relevant for abdominal aortic aneurism (AAA) repair

Code	NCSP	ICD-10		
	Chapter PD: infrarenal aorta and iliac arteries	AAA	Aortic occlusion	Iliac aneurysm
	Section; PDG: operation for aneurysm in the infrarenal abdominal aorta and iliac arteries*			
PDG10	Operation on the infrarenal aorta for aneurysm.	I71.3,4,8,9	None	None
PDG20	Bypass from aorta to iliac artery for aneurysm	I71.3,4,8,9	None	I72.3
PDG21	Bypass from aorta to bilateral iliac arteries for aneurysm	I71.3,4,8,9	None	I72.3
PDG22	Bypass from aorta to iliac artery and contralateral femoral artery for aneurysm	I71.3,4,8,9	None	I72.3
PDG23	Bypass from aorta to femoral artery for aneurysm	I71.3,4,8,9	None	I72.3
PDG24	Bypass from aorta to bilateral femoral artery for aneurysm	I71.3,4,8,9	None	I72.3
	Section; PDQ: implantation of endovascular prosthesis in the infrarenal abdominal aorta and iliac arteries			
PDQ10+PDQ30	Implantation of endovascular prosthesis in infrarenal aorta	I71.3,4,8,9	I70.0	None
	Implantation of endovascular prosthesis in iliac artery	I71.3,4,8,9	I70.2	I72.3
	Section; PDS: endoscopic operation on the infrarenal abdominal aorta and iliac arteries			
PDS10	Endoscopic operation on the infrarenal abdominal aorta	I71.3,4,8,9	I70.0	None

For aortic occlusion without AAA the relevant chapter for conventional bypass in NCSP is PDH; bypass from infrarenal aorta and iliac arteries.

* Reoperations after earlier reconstruction are to be coded in NCSP as PDU.74-99.

identification-number for each patient. The selection from this registry could, therefore, easily be controlled for double case registrations, which we did not find. In the vascular registry, the design of the database allows for double registration of both operations and patients, as there is no unique patient key. If two cases of the same age and sex, coming from the same county, were operated in the same hospital on the same day with exactly the same procedure-code and similar diagnoses, only one of these records was included in the evaluation.

Completeness of the reporting to our vascular registry was estimated according to numbers of the administrative registry assuming a nearly complete registration in the latter.

To correct for overall completeness of reporting from each hospital when studying reported in-hospital deaths in the vascular registry, we defined relative completeness as; completeness of reported in-hospital deaths divided by overall completeness of reporting to the vascular registry for each hospital.

The retrospective control of one local vascular database was done by additional searches through the operation registry and the anaesthesiological registry of one member-hospital. All patients with any recorded data indicating AAA was evaluated. The recorded diagnosis and procedure-codes were controlled in the medical record for each individual patient.

Data were retrieved from the two registries on Microsoft Excel® files and handled in Microsoft Access®. For statistical analysis we used SPSS 11.0 for Windows®. The investigation was approved by the local ethics committee.

Results

Completeness and consistency of data

For the period 2001 and 2002, we identified 1544 cases

Table 1B. Relevant ICD-10 diagnosis codes for the study of AAA-treatment

ICD-10	Text*
Section I71	Aortic aneurysm and aortic dissection
I71.3	Abdominal aortic aneurysm with rupture
I71.4	Abdominal aortic aneurysm without information of rupture
I71.8	Aortic aneurysm with undefined localisation, with rupture
I71.9	Aortic aneurysm with undefined localisation and without information of rupture
Section I72	Other aneurysm
I72.3	Aneurysm of iliac artery
I72.9	Aneurysm with undefined localisation
Section I70	Atherosclerosis
I70.0	Atherosclerosis of the aorta
I70.2	Atherosclerosis of artery in limb

* Translation of the Norwegian version.

with the relevant procedure-codes in the national administrative registry (NPR) reported from 29 different hospitals. Of these, 21 cases were excluded because the data were consistent with treatment for isolated iliac aneurysm or stent grafting of aorto-iliac obstructive disease. This left a total number of 1523 treatments for AAA in this registry (Table 2).

A corresponding search in the national vascular registry (NorKar) showed 1055 cases treated for AAA in 17 member hospitals after the exclusion of 18 case-doublets together with 15 cases for which coding was consistent with other indications for surgery. Thus, 69% of the total national number of treatments for AAA was reported to the vascular registry and within the member hospitals the completeness of reporting was 84%. Endoscopic aortic operation (PDS10) was not performed in any cases.

The number of cases where procedure- and diagnosis-code was consistent according to Table 1A, was 1417 (93.0%) for NPR and 990 (93.8%) for NorKar (Table 3). In non-member hospitals there was consistency in 242 of 265 cases (91.3%). For several hospitals the consistency of the data reported differed between NPR and NorKar.

In the administrative registry 362 cases (23.8%) had ruptured AAA according to their ICD-10 diagnosis. One thousand and fifty five cases (69.3%) were coded as having non-ruptured AAA, while in 106 cases (7.0%) the diagnosis-codes were not suited for classification of rupture status. In the vascular registry the number of cases with ruptured AAA was 244 (23.1%) according to the diagnosis, 746 (70.7%) were non-ruptured, while 65 cases (6.2%) could not be classified.

Completeness of ruptured cases was 72.5% in the vascular registry and 86.1% for non-ruptured cases. For cases where status of rupture could not be assessed from the ICD-10 coding, completeness was 78.3%.

According to data from the vascular registry, 34 procedures (3.2%) were secondary to a former vascular procedure. In the Norwegian patient registry there is no variable to discriminate between primary and secondary procedures in a similar way.

Table 2. Operations for AAA performed in Norway according to Norwegian patient registry, NPR, and in 17 member-hospitals according to the Norwegian vascular registry, NorKar, during the period 2001–2002

Operation	NPR, *N* (%)	NorKar, *N* (%)
Tube graft	885 (58)	633 (60)
Bifurcated graft	491 (32)	320 (30)
EVAR	132 (9)	91 (9)
Combinations	15 (1)	11 (1)
Total	1523	1055

Mortality

The reporting of in-hospital mortality varied strongly between different hospitals and between the administrative registry and the vascular registry within each individual hospital (Table 4). Some hospitals reported less than 50% of their in-hospital deaths to the vascular registry. Compared to numbers from the administrative registry, only 60% of patients who died in the hospital were reported to the vascular registry by the members, and the relative completeness of reporting in-hospital deaths was 72.3% (95% CI 65.2–79.4).

In the administrative registry, the crude national in-hospital mortality was 33.7% for ruptured and 5.0% for non-ruptured AAA (Table 5). In the vascular registry the corresponding mortality rates were 29.9% for ruptured and 3.1% for non-ruptured AAA, respectively, and mortality in member hospitals did not seem to differ from non-member hospitals.

Work-up of one local vascular database

The detailed evaluation involving one NorKar Local Registry showed that 134 patients met the search criteria (PDG10-24 or PDQ10). One patient was correctly coded, but not included because he was treated for an isolated iliac aneurysm. Of the remaining 133, two were found to be case-doublets, while further five patients were incorrectly included due to false procedure-codes (Table 6). The evaluation also revealed 10 patients in the database with registered data that could implicate AAA, but who had been lost to inclusion due to false coding of procedures. Further, we examined the records of 20 patients coded as operation for aorto-iliac occlusion with implantation of a bifurcated vascular graft (PDH20-24), but they were all correctly coded. By matching of the database with the local anaesthesiology registry, we found three patients that met the inclusion criteria, but who had been lost to registration in the vascular registry. Thus, the completeness of this NorKar local registry was 90.6 and 5.3% of the registered cases were falsely coded or doublets.

Discussion

Completeness of data

The reporting to the Norwegian patient registry is likely to be nearly complete because the reporting is compulsory for formally discharging a patient from hospital and to get reimbursement from the health

Table 3. Completeness of the Norwegian vascular registry, NorKar, compared to Norwegian patient registry, NPR, and consistency between diagnosis and procedure-codes in the two registries, for patients treated for AAA in Norway during the period 2001–2002

Hospital	Number of operations 2001–2002*	Completeness	Procedure-diagnosis-consistency	
		NorKar/NPR (%)	NPR (%) (range)	NorKar (%)
NorKar members				
A	>100	87.7	96.6	96.0
B	>100	93.7	95.4	97.0
C	>100	77.0	95.1	95.7
D	>100	94.1	95.1	96.9
E	>100	92.6	92.6	92.7
F	40–100	94.8	81.7	88.2
G	40–100	73.6	90.3	92.6
H	40–100	97.4	98.8	89.9
I	40–100	80.9	91.2	89.1
J	40–100	99.0	94.8	96.9
K	10–39	100	95.7	81.6
L	10–39	50.0	100	100
M	10–39	6.4	91.6	100
N	10–39	100	92.3	96.2
O	10–39	100	97.9	97.9
P	10–39	41.4	92.7	100
Q	10–39	13.8	92.8	96.0
Non-members†				
R1-2	40–100	–	91.4 (87.8–95.3)	–
R3-6	10–39	–	91.5 (87.9–97.3)	–
R7-12	<10	–	88.9 (50–100)	–
NorKar members	1258	83.9	93.4	93.8
Non-members	265	–	91.3	–
All	1523	69.3	93.0	–

* According to NPR numbers.
† Hospitals that were not members of NorKar are named R1-12.

Table 4. Reporting of in-hospital deaths following AAA repair for individual hospitals according to the Norwegian vascular registry, NorKar and Norwegian patient registry, NPR, and completeness of reporting in-hospital deaths to NorKar, in the years 2001–2002

Hospital	Number of operations 2001–2002*	Crude mortality NPR (%)	Crude mortality NorKar (%)	Completeness* of reported deaths (%)	Relative completeness† % (95% CI)
NorKar members					
A	>100	15.8	8.0	44.4	50.6
B	>100	9.8	6.0	57.1	61.0
C	>100	7.4	9.6	100	130.0
D	>100	11.7	7.1	58.3	61.3
E	>100	15.5	16.8	100	108.0
F	40–100	1.4	1.5	100	104.4
G	40–100	19.4	3.8	14.3	19.4
H	40–100	18.5	17.7	93.3	95.7
I	40–100	16.2	3.6	18.2	22.5
J	40–100	7.2	5.2	71.4	72.2
K	10–39	18.4	15.8	85.7	85.7
L	10–39	10.0	0	0	0
M	10–39	6.4	0	0	0
N	10–39	11.5	15.4	100	133.3
O	10–39	4.2	4.2	100	100
P	10–39	17.1	17.7	42.9	103.4
Q	10–39	27.6	0	0	0
Non members‡					
R1-2	40–100	8.7	–	–	–
R3-6	10–39	11.9	–	–	–
R7-12	<10	22.2	–	–	–
Members	1258	12.3	8.9	60.6	72.3 (65.2–79.4)
Non-members	265	10.6	–	–	–
Total	1523	12.0	–	–	–

* According to NPR.
† Relative completeness = reported in hospital deaths (%)/overall completeness of reporting (%).
‡ Hospitals that were not members of NorKar are named R1-12.

Table 5. Reporting of in-hospital deaths for ruptured and non-ruptured AAA in the Norwegian vascular registry, NorKar and Norwegian patient registry, NPR, in the years 2001–2002

Hospital	Number of operations 2001–2002*	Rupture NPR (%)	Rupture NorKar (%)	Non-rupture NPR (%)	Non-rupture NorKar (%)
NorKar members					
A	>100	30.4	21.2	4.7	1.6
B	>100	27.3	19.4	3.9	0
C	>100	28.0	30.4	2.2	3.0
D	>100	42.9	28.6	6.0	3.7
E	>100	41.2	53.6	8.7	8.1
F	40–100	0	5.9	2.4	0
G	40–100	40.0	10.0	8.9	2.6
H	40–100	50.0	45.5	5.4	6.1
I	40–100	46.7	14.3	8.5	2.4
J	40–100	25.9	16.7	0	0
K	10–39	30.8	30.0	13.0	9.5
L	10–39	100	0	0	0
M	10–39	28.6	0	2.8	0
N	10–39	20.0	30.0	7.1	6.7
O	10–39	33.3	28.6	0	0
P	10–39	83.3	100	3.1	6.7
Q	10–39	36.4	0	15.4	0
Non members†					
R1-2	40–100	25.0	–	4.7	–
R3-6	10–39	33.3	–	3.7	–
R7-12	<10	33.3	–	0	–
Members	1258	33.7	29.9	5.0	3.1
Non-members	265	29.6	–	4.2	–
Total	1523	33.1	–	4.8	–

In 6.1% (65 patients) in NorKar and 6.9% (105 patients) of the patients in NPR presence of aneurysm rupture could not be decided from the coding.

* According to NPR.

† Hospitals not being members of NorKar are named R1-12.

authorities. In our national vascular registry there is no economic motivation or administrative demands for reporting to the registry. The participation in the registry is not compulsory and the required workload and resources must be covered by each participating hospital. This can explain some of the discrepancy in numbers reported to the two registries for some member hospitals. Although data may be complete, there is also the possibility that the administrative registry may be overestimating the number of cases. Transfer of patients from one hospital to another postoperatively, may result in reporting of the same procedure-codes in both hospitals, and thus falsely increase the numbers of procedures reported. Due to the anonymous capacity of the data, the presence or magnitude of such over-reporting could not be assessed by this study. During recent years there has been criticism of the coding done by Norwegian hospitals, and the Office of the Auditory General of Norway has concluded that false coding has artificially raised the reimbursement to some hospitals. Because, operation for AAA is a demanding procedure, which requires large resources, over-reporting of this procedure may give economical benefits for the hospital.[9] It is our opinion that completeness of data cannot be firmly established before both registries include patient-identifiable data. This will improve the quality of both registries by making matching of data on patient level possible.

Table 6. Control of data on AAA-treatment in one local vascular database (NorKar Local Registry) in the period 2001–02

	N (%)
Patients included from the search in the NorKar local registry	133
Falsely included*	−7 (5.3)
NorKar patients lost to inclusion due to false procedure-code†	10 (7.2)
Patients lost to NorKar‡	3 (2.2)
Total 2001–02	139

* Two doublets.

† Found by controlling of patients registered in the NorKar local registry with data implicative of AAA who did not meet the search criteria on procedure-code.

‡ Found in the local anaesthesiological registry.

Diagnosis-procedure-consistency

Lack of procedure-diagnosis-consistency is a major problem since both the procedure-code and the diagnosis-code may be false. Misclassified patients may, therefore, either be lost or falsely included. The number of patients in this study may be overestimated because, cases with procedure-codes for AAA treatment but no ICD-10-code of AAA are included. However, reported patients with false procedure-codes may on the other hand have been lost to inclusion. To improve the quality when entering the data, algorithms and control-mechanisms of consistency should be implemented in the registration software. A study has also indicated that doctors' participation has raised the quality of coding,[10] but this has not guaranteed for satisfactory data quality in the Norwegian vascular registry.

Reporting of in-hospital mortality

Hospital mortality or 30d mortality are the most reproducible data when reporting on early results after treatment for AAA. This audit shows that there is great discrepancy between mortality reported by various hospitals in two different registries. The relative completeness of reported in-hospital deaths of 72%, strongly suggests a systematic underreporting to the vascular registry. There can be several reasons for this finding, and the explanation may differ between hospitals. Different routines when formally discharging patients that die during the hospital stay compared to those who survive may be one of the reasons for the underreporting to the registry. Furthermore, patients dying from complications after an AAA operation may be taken care of by other groups of personnel like anaesthesiologists or cardiologists who may be unaware of the vascular registry. Finally, one cannot exclude the possibility that some departments are less willing to report unfavourable results. No matter the reason, early mortality is probably the most crucial quality parameter in treatment of AAA, and it is the responsibility for the chief of any vascular department to make sure that the numbers presented in any registry are correct.

Validation of one local vascular database

The reason for doing the separate control of one NorKar Local Registry was mainly to estimate the efficacy of our inclusion criteria based on the defined procedure-codes. The control showed that 9.4% of all the patients operated for AAA, were not identified by our search in the local vascular database using our inclusion criteria. The possibility that patients have been lost to all hospital registries, and thus lost to our control, is probably small. The finding that 7.2% were registered with false codes, and that only 2.2% had not been recorded indicates that the greatest potential for improvement is in quality control of coding and data-entry. In addition, regularly matching of the local vascular database with other registries in the hospital would probably improve the completeness of data considerably.

Problems in coding

Since endovascular aortic aneurysm repair (EVAR), was established in Norway 1995, the coding for stent-grafting for AAA has been the same as the code used for aortic stent-implantation in atherosclerosis obliterans (ASO), although the devices are different. In contrast, the codes for implantation of bifurcated vascular grafts for aneurysm and obliterating atherosclerosis are divided into two different categories (PDG and PDH) according to indication, although the general surgical methods are similar and that indication is not supposed to be an inherent part of the NSCP system. The fact that it is for implantation of bifurcated graft, means that patients treated for concomitant AAA and ASO, cannot be coded for both indications. This may have resulted in an underestimation of concomitant treatment of aorto-iliac occlusion in patients treated for AAA.

Secondary procedures are relatively rare in open surgery for AAA, but have become quite common after the introduction of EVAR.[11] In the vascular registry there is a unique variable to classify the procedure as primary or secondary. In our national administrative registry there is no variable for classification of the procedure as primary or secondary to a previous operation for AAA. However, when assessing the procedure-codes we observed an inconsequent coding of secondary procedures, and thus we were unable to compare the registries according to this capacity. Clearer guidelines in coding and proper instructions of participating surgeons therefore seem mandatory.

Registry based studies

As medical registries and registry based reports are getting more common, we have tried to demonstrate some of their limitations and the need for quality control of data. Our study has shown that important information on AAA treatment can be attained from the two different registries. Early mortality, length of stay in hospital, numbers treated and age of treated patients is information that can be achieved from a public patient registry like NPR. For data on risk factors, surgical details, results and case-mix, a vascular registry based on reproducible data filled in by qualified staff is mandatory.

There is need for defined strategies to assure for the correctness of data. These may include proper instruction of attending physicians, controlled entry of data and algorithms to ensure consistency of data. One possible strategy to obtain completeness of data as demonstrated in our study, is matching of different registries. To be able to check up on and further correct false registrations, patient identifiable data is mandatory. Otherwise matching can only provide an estimate for data quality. To avoid that assumptions are based on systematic weakness of data like under-reported in-hospital deaths, registry based studies must address the completeness and limitations of the data presented.

Conclusion

The evaluation showed an underreporting of procedures in patients with AAA to the national vascular registry (NorKar) relative to the national administrative registry (NPR), and demonstrates a need for better control of procedure-diagnosis consistency in both registries. Consistency of data could probably be improved by introducing algorithms in the entry software of the databases. There seems to be a substantial underreporting of early deaths in the vascular registry that calls for further investigations. Finally, we suggest that the two registries are made patient identifiable to facilitate improvement of data quality in general.

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Paper VI

Infrarenal abdominal aortic aneurysm repair

Time-trends and results during a 20-year period

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Original article

Short title: Time trends in AAA treatment

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Abstract

Background

Our aim was to investigate the number of operations for abdominal aortic aneurysms (AAA) including time-trends in treatment during a 20-year period.

Method

1045 patients treated with open surgery (906) or EVAR (139) were treated for AAA during the period 1983-2002. Number of operations, risk factors, anaesthesia time and operating time were investigated. Data were either collected retrospectively from the patient's medical records or from the Norwegian National Vascular Registry.

Results

There was an increase in the number of operations for both ruptured and non-ruptured AAA in men during the study period. Among women, the increase was observed only for ruptured aneurysm. Operating time and anaesthesia time increased during the 20-year period. Early mortality (<30 days) was 4.8 percent in the elective group, 18.9 percent in the emergent non-ruptured group operated within 24 hr of admittance, and 41.6 percent in the ruptured group. Women with ruptured AAA experienced a higher 30-day mortality than men, 57.1 and 37.4 percent respectively (p-value = 0.006). Excluding 30-day mortality, the long-term mortality was similar for patients with non-ruptured and ruptured aneurysm. We observed an improvement in long-term survival over the last 20 years (p-trend = 0.02).

Conclusion

There has been an increase in the number of AAA operations for rupture both in men and women, and in male patients there was also an increase in elective operations. There has been an increase in anaesthesia and operating time. Provided the patient is surviving the operation, the long-term prognosis is comparable for ruptured and non-ruptured. Long-time survival seems to have improved during the study period.

Introduction

During the last decades the incidence of abdominal aortic aneurysm (AAA) has been increasing, also after adjustment for the increasing number of elderly in the population (1). Simultaneously, endovascular repair (EVAR) has emerged as a new option for treating AAA. Encouraging early and mid-term results have been presented (2, 3), but the technology is not perfect (4).

There is a substantial proportion of patients who are unfit for treatment by EVAR from an anatomical point of view, and the long-term results are still uncertain. Encouraging results have also been presented with EVAR following ruptured AAA (5). However, due to problems with resources and logistics, open surgery is still the method of choice in most centres.

The aim of the present study was to investigate prognostic factors for early and long-term mortality in a cohort of patients operated for AAA during a 20-year period. Finally, we studied trends and changes in number of operations, operating time and anaesthesia time over the 20-year calendar period.

Material and methods

During the 20-year period 1983 – 2002, 1045 patients were treated with either open operation (906) or EVAR (139) for AAA at our institution. The median age at operation was 71 years, and women constituted 17% (n=178) of the cohort. 504 of the patients were admitted to the hospital as emergencies, and 298 (28.5%) of the patients had a ruptured aneurysm. 206 patients with non-ruptured AAA were admitted as emergencies, mainly due to symptoms. These patients were categorized into emergency non-ruptured or elective according to whether they were operated within 24 hours after admission or not.

A prospective national vascular registry (6) was established in 1995, and information concerning patients treated between 1995 and 2002 were retrieved from this registry locally. Data for patients operated 1983 to 1994 were collected retrospectively from the patients' medical records. To make matching of data from the early and the late period possible, we used the same definitions when collecting data.

Information on risk factors like coronary heart disease (angina pectoris, myocardial infarction or treatment with aorto-coronary bypass / percutaneous coronary intervention), renal failure (serum creatinin concentration >140 µmol/l), chronic obstructive pulmonary disease (COPD) and major postoperative complications were extracted for each patient.

Completeness of the cohort has been thoroughly checked using the registries of the department of surgery and the department of anaesthesiology. In addition we also examined the protocols at the operating department. Anaesthesia time was defined as the total time that the patient spent in the operating room. Only patients treated primarily for AAA with open operation or EVAR were included. EVAR was introduced at our department in February 1995. The cohort has been checked for double registration (case doublets) by matching on personal ID-numbers. Data on follow-up was based on the Norwegian Registrar's Office of

Births and Deaths, which is updated every 14 days. A 100 % follow-up was obtained. The investigation was approved by the local ethics committee.

Statistics

Linear regression analyses were used to evaluate trends over calendar time in the annual numbers of AAA operations, and in the mean operation and anesthesia time. In these analyses we adjusted for mean age in the respective combinations of year, sex and type of operation. 30-day mortality was evaluated using a two samples proportion test for univariate comparisons, and logistic regression for multivariate analyses of potential prognostic factors. Long term survival was estimated using univariate Kaplan-Meier analyses, and potential prognostic factors were evaluated in multivariate Cox proportional hazards regression models after the exclusion of 30 day mortality.

In the final model statistic significant and/or clinical relevant variables were included.

Analyses were performed using SPSS version 12.0 (SPSS, Chicago, Illinois, USA).

Results

Number and type of operations

The overall number of operations for AAA increased significantly ($p<0.001$) during the study period (Figure 1). The number of operations for non-ruptured as well as ruptured aneurysm increased significantly in men (both p-values <0.01). In women there was only an increase in operations for ruptured aneurysm ($p=0.004$) whereas the number of operations for non-ruptured AAA remained relatively constant during the study period. The proportion of patients with non-ruptured AAA operated within 24 h of emergency admittance dropped from 16.6 percent in the period before 1995 to 3.4 percent in the period from 1995 to 2002 (p-value<0.001). There was a change in use of vascular grafts from bifurcated to tube grafts during the twenty year period (Figure 2), and introduction of EVAR did not seem to diminish this steadily increasing proportion. Since 1995 EVAR has been used to an increasing extent, and constituted 40% of all operations for non-ruptured AAA in the last five years from1998 to 2002. The mean age at operation increased from 69.3 years in 1983-87 to 71.7 in the last 5 year period. Correspondingly, the proportion of octogenarians has increased from 8.7% to 12.2%. The number of patients from the neighbour counties operated on for AAA at our institution also increased during the study period, corresponding with the increasing total number of patients, constituting a constant proportion of about 20 %.

Fig.1

Fig. 2

The median aneurysmal diameter, measured with CT scanning or ultrasonography, in the ruptured, emergency non-ruptured and elective groups was 72, 65 and 57 mm respectively.

Early operative results

The operating time increased significantly during the study period, accompanied by an even more pronounced increase in anaesthesia time (Figure 3). The early mortality (< 30 days) was 4.8% for elective operations, 18.9 % in the emergency non-ruptured group and 41.6% in the

Fig.3

rupture group (Table 1). Although women tended to have lower 30-day mortality after repair of non-ruptured AAA compared to men, 3.0% vs. 5.1% respectively, women had significantly higher 30-day mortality after repair of ruptured AAA (57.1% vs. 37.4%, p=0.006). Table1

Using multiple logistic regression analysis, age at operation, cerebrovascular disease, and renal failure were all significantly associated with 30-day mortality (Table 2). Table 2 Patients with non-ruptured AAA operated within 24 hours of an emergency admission had an odds ratio of 4.9 (95% confidence interval (CI) 2.4-9.9) of early death compared to those who were operated electively.

Altogether 7.4% of the patients needed an early reoperation (< 30 days), and haemorrhage, bowel necrosis and intestinal obstruction were the most frequent reason for the procedures. Median stay at the hospital was similar after operation for ruptured (12 days) and for non-ruptured aneurysms (14 days). Hypertension and cardiac disease were the most prominent risk factors and trend-analysis did not indicate substantial changes in the prevalence of co-morbidities over the period.

Long term survival

As expected, the overall survival probability was highest in the non-ruptured group and lowest following operation for ruptured aneurysm. However, when excluding the 30-day mortality, the long-term survival was almost similar for the two groups (Figure 4). Fig.4 Overall 5-years survival was 46.6% for women compared to 57.0% for men. Following repair of ruptured AAA the 5-years survival was 24.3% and 41.3%, respectively. In patients with non-ruptured aneurysm the 5-year survival was 65.7% in men compared to 58.9% in women respectively. Factors influencing long term mortality in patients surviving 30 days after operation were investigated using multivariate Cox regression. Cerebrovascular disease, diabetes, COPD and renal failure were all significant prognostic factors for long-term mortality (Table 3). We observed an improvement in long term survival over the four 5-years operation periods (p-trend = 0.004).

Discussion

Number and type of operations

The reasons for the increasing number of AAA operations during this 20-year period are probably multifactorial. The incidence of AAA is increasing with increasing age, and since the elderly part of the population is increasing, the number of AAA operations is expected to increase. However, the number of AAA operations is increasing also when correcting for age, thus there must be additional reasons for the increase observed. The tendency of using non-invasive methods like ultrasonography and computed tomography scans for various abdominal diseases has increased substantially, and a large proportion of our patients had their AAA detected following such diagnostics. Also, the introduction of EVAR has widened the indications for treating AAA, especially in patients unfit for open surgery including those who are elderly with co-morbidities.

We can only speculate why the number of operations for non-ruptured AAA in female patients was relatively unchanged during the study period, whereas there was an increase in the number of operations for rupture. It has been documented that female patients with AAA have a higher tendency to rupture (7) and further, women have an increased growth rate of their aneurysm (8). Female gender also has an Odds ratio of 3 (CI 1.7-5.2) as a predictor for operative death after repair of ruptured AAA (9). All factors indicate that AAA in women is a more malignant condition than in men. Women get their AAA at a higher age compared to men (1) and it has previously been shown that women are less likely than men to be admitted to hospital and operated for ruptured AAA (10). It is possible that the diagnosis AAA is not taken into consideration as a differential diagnosis in women to the same extent as in male patients. Our data and especially the 30d mortality indicate that more women should probably have been operated on electively, and this question needs to be investigated more thoroughly.

One might have expected that an increasing number of elective operations would have lead to a decreasing number of patients needing treatment for rupture (11). However this is a controversial topic and various results have been reported in the literature (9, 12). It has been stated that the number of elective operations must be increased considerably before one can expect a drop in the incidence of rupture in the population (13). The problem is obviously to treat the right patients at the right time. Perhaps basis of the present indication for surgery, which to a great extent is relying on aneurysm diameter, is insufficient. One possibility is to use aortic strain measurements, which perhaps in the future might help improving the selection of patients needing treatment (14). We have previously shown a substantial increase in the number of octogenarians operated electively during the period (15), which might reflect a stronger expectation of treatment even for patients with relatively short expected survival. The relatively high early mortality in octogenarians may however question the benefit from open AAA- surgery in this group of patients (16). The tendency of using more straight aortic grafts during the study period probably reflects a tendency of neglecting minor pathologic changes of the iliac arteries. Theoretically this should have lead to a shorter operating time, but there is often calcification located near the aortic bifurcation, which could lead to technical difficulties during performance of the anastomosis.

Operating time and anaesthesia time

We observed an increase in the median operating time of more than one hour, and an even more pronounced increase in anaesthesia time of nearly 1 hour and a half during the 20 year calendar period. As more patients are treated with EVAR, one could probably anticipate that those operated with open surgery are more complicated from a technical point of view. However, this development was apparent even before introduction of EVAR and might reflect that more time for performing the surgery and for doing the anaesthesia is needed in a teaching hospital with several residents training in vascular surgery and anaesthesiology. Furthermore the staff has increased, leading to a lower number of operations per surgeon during the study period. However, teaching institutions, including our own, are trying to give the trainees sufficient experience by using qualified consultants as assistants during the operations, which again should assure that the training situation is not affecting operating time, early mortality or complication rate.

The increased anaesthesia time probably reflects some of the same problems. With more residents in anaesthesiology, the time for preparation may increase. Furthermore there might have been changes in the routine of monitoring these patients, which also includes more technical devices that must be established before the operation can start (17). We did not find any evidence for increased co-morbidity among the patients during the study period.

Early results

In patients with ruptured AAA, the early mortality has been relatively unchanged during the study period. The observed 30-day mortality of 41.6 % in these patients is high, but in accordance with other publications (18). The high 30-day mortality following operation for rupture in female patients is difficult to explain, particularly since the distribution of prognostic risk factors was similar among men and women. The finding is, however, known from other studies (19-21). It has been speculated whether female patients have more concomitant diseases than male patients, although evidence for this was not found in the present study.

We have previously discussed the relatively high mortality in patients without rupture admitted as emergencies for AAA and operated on within 24 hours of admittance, and have suggested the term emergency non-ruptured AAA for these patients (22). Previously our policy was to operate them soon after admission to avoid rupture. The trend during recent years has been to do a CT-scan first to exclude rupture in stable patients admitted as emergencies. Thereafter, diagnostic investigations have been performed as necessary and the patients are now to a greater extent operated in a more elective setting, and preferably during daytime with the necessary expertise and resources available. We hope that this change in practice might have prevented early deaths after operation during recent years (23).

Long term survival

When excluding the operative mortality, the long-term survival was similar in patients operated for rupture and non-ruptured aneurysm. Recently it has been documented that EVAR decreases the primary mortality significantly, and mid-term results are also promising (2, 3). More long-term follow-up is, however, needed before more conclusive evidence on EVAR can be reached, and currently only about 50% of the patients are suitable for the application of EVAR from an anatomical point of view.

We observed a significant decreasing trend in the long term mortality over the 20-years operation period. The explanation could be a different case-mix in the various 5-year periods. Furthermore, better treatment of co-morbidities like cardiac, pulmonary and kidney disease could also explain this finding. Although not statistically significant, women had an overall reduced long-term mortality compared to men in our material, which is in agreement with other reports (21). This might further strengthen the hypothesis that AAA in women are stronger associated with co-morbidities with impact not only on early mortality but also on long term survival. Based on the possible under-treatment and higher risk compared to men, more studies should therefore focus on women with AAA.

Conclusion

The number of AAA operation nearly doubled in the calendar period between 1983 and 2002.. There has been an increase in anaesthesia and operating time of more than one hour, which need further assessment. Women with ruptured AAA have a higher early mortality than men, and the reasons for this needs to be clarified. Long-term survival seems to have improved during the study period.

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Legend for figures

Figure 1

Operations for AAA in men (left) and women (right) recorded in 5-year time spans during the period 1983-2002.

Figure 2

Operations for AAA in 5-year time spans during the period 1983-2002 according to the use of Y-grafts, I-grafts and EVAR.

Figure 3

Median operating time (left) and anaesthesia time (right) for AAA by in 5-year time spans during the period 1983-2002.

Figure 4

Long-time survival among patients operated on for AAA according to rupture and non-rupture after exclusion of early mortality (less than 30 days).

Table 1. Early mortality(<30 days) in 1045 patients operated for AAA at St.Olavs hospital in Norway during the period 1983-2002.

	Overall	Ruptured	Non - ruptured	
30-days mortality			Emergency (<24 hr)	Elective
	N=1045	n = 298	n = 74	n = 673
Both sexes % (SE [a])	16.3 (1.1)	41.6 (2.9)	18.9 (4.6)	4.8 (0.8)
-women % (SE)	24.2 (3.2)	57.1 (6.2)	25.0 (10.8)	3.0 (2.0)
-men % (SE)	14.6 (1.2)	37.4 (3.1)	17.2 (8.6)	5.1 (0.9)

[a] SE= Standard error

Table 2. Logistic regression of 30-day mortality among ruptured, emergency (operated within 24 hr), and elective patients operated on for AAA from 1983 to 2002 according to preoperative risk factors adjusted for age at operation and sex,

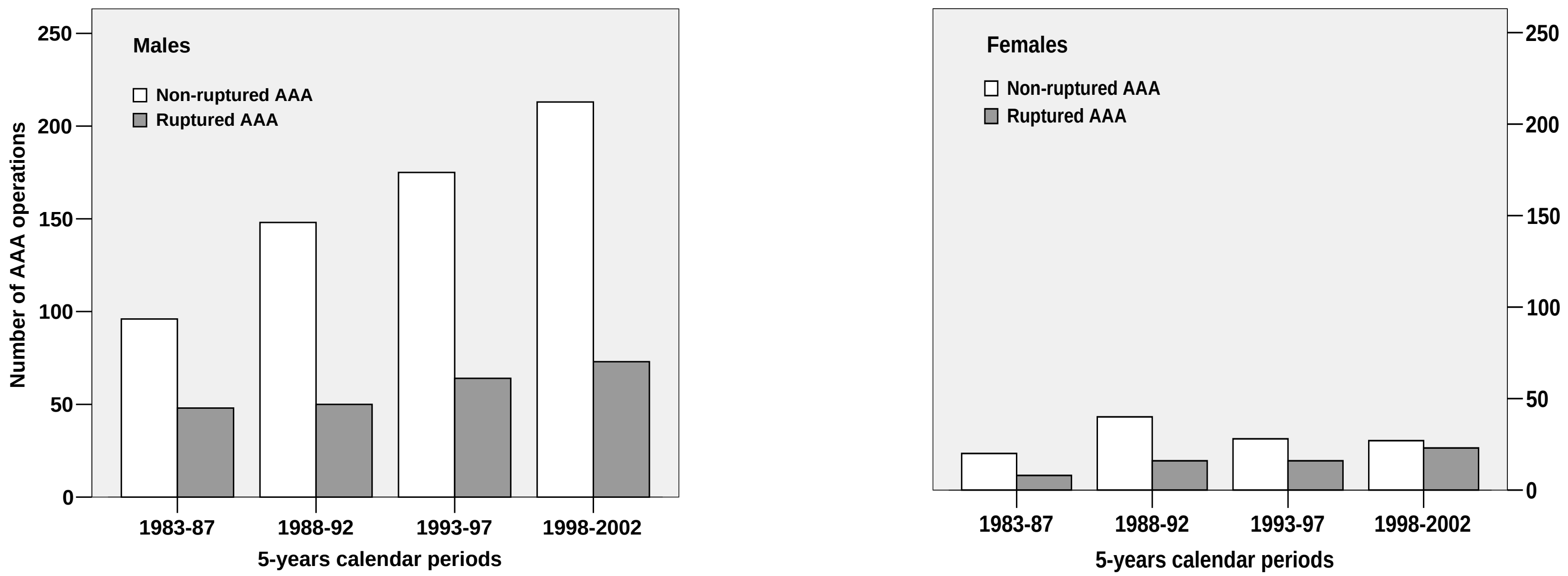
Variable	Odds ratio	95% CI	p-value
Cerebrovascular disease	1.8	1.1-3.1	0.03
COPD	1.5	0.9-2.5	0.14
Renal failure	1.9	1.1-3.3	0.02
Patient group			<0.0001
elective	1.0	reference	
emergency (<24 hr)	4.9	2.4-9.9	
rupture	12.4	8.0-19.4	

Additional adjustments for diabetes, cardiovascular diseases and hypertension did not change the results (neither were these risk factors significant, all p-values >0.3)

Table 3. Cox regression of factors influencing long term mortality after the exclusion of operation related mortality (30-day mortality)

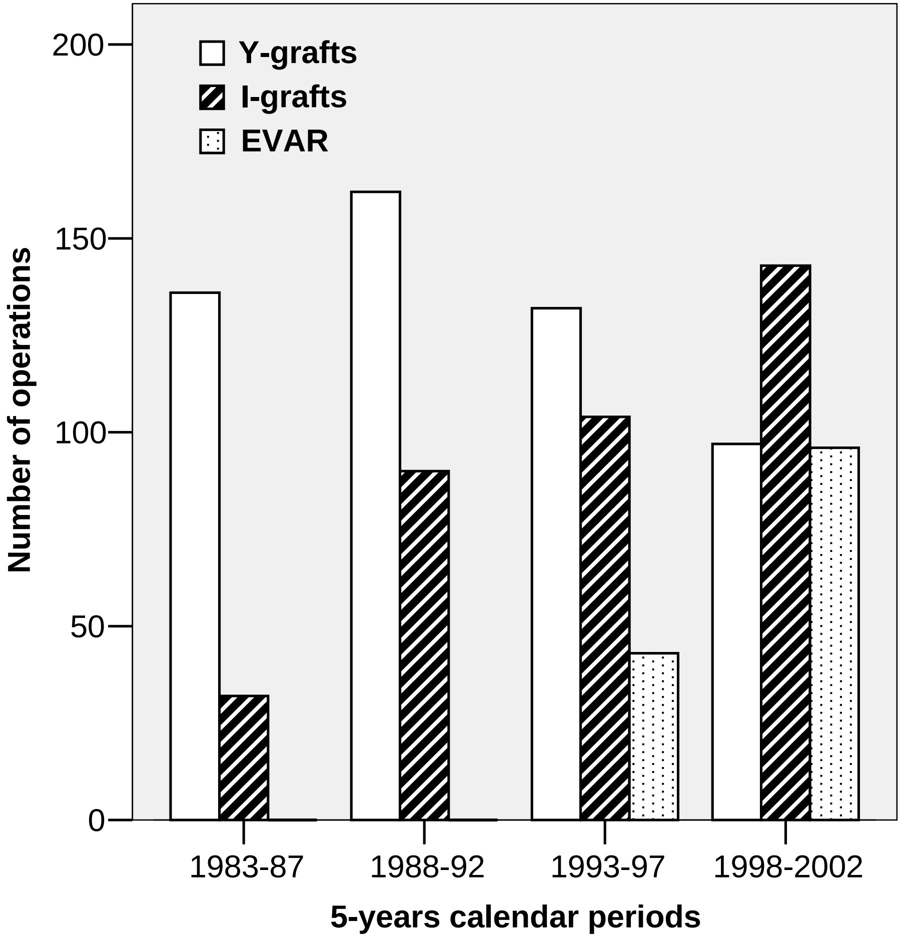
	Relative risk	95% CI	p-value
Age at operation	1.06	1.05-1.08	<0.0001
Sex			0.21
Female	1.00	reference	
Male	0.86	0.68-1.09	
Operation period			0.018
1983-1987	1.00	reference	
1988-1992	0.93	0.74-1.18	
1993-1997	0.69	0.53-0.91	
1998-2002	0.70	0.51-0.97	
Cerebrovascular disease	1.56	1.20-2.04	0.001
Diabetes	1.55	1.04-2.31	0.033
COPD	1.45	1.11-1.89	0.006
Renal failure	1.47	1.06-1.99	0.019
Operation group			0.56
elective	1.00	reference	
rupture	1.07	0.85-1.34	

Figure 1



Males
Non-ruptured AAA
Ruptured AAA
Number of AAA operations
250
200
150
100
50
0
1983-87
1988-92
1993-97
1998-2002
5-years calendar periods
Females
Non-ruptured AAA
Ruptured AAA
250
200
150
100
50
0
1983-87
1988-92
1993-97
1998-2002
5-years calendar periods

Figure 2.



Y-grafts
I-grafts
EVAR
200
150
100
50
0
Number of operations
1983-87
1988-92
1993-97
1998-2002
5-years calendar periods

Figure 3.

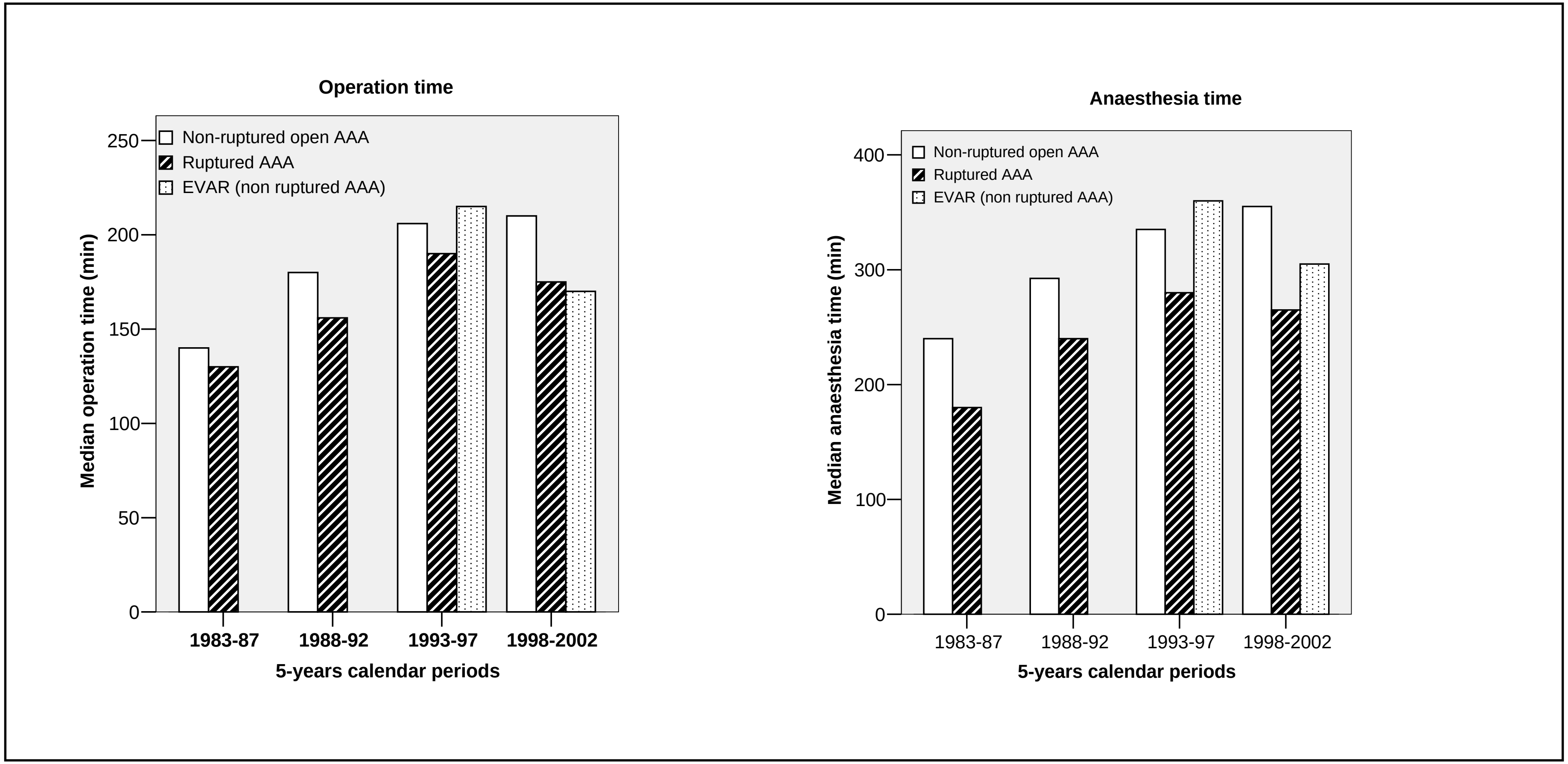
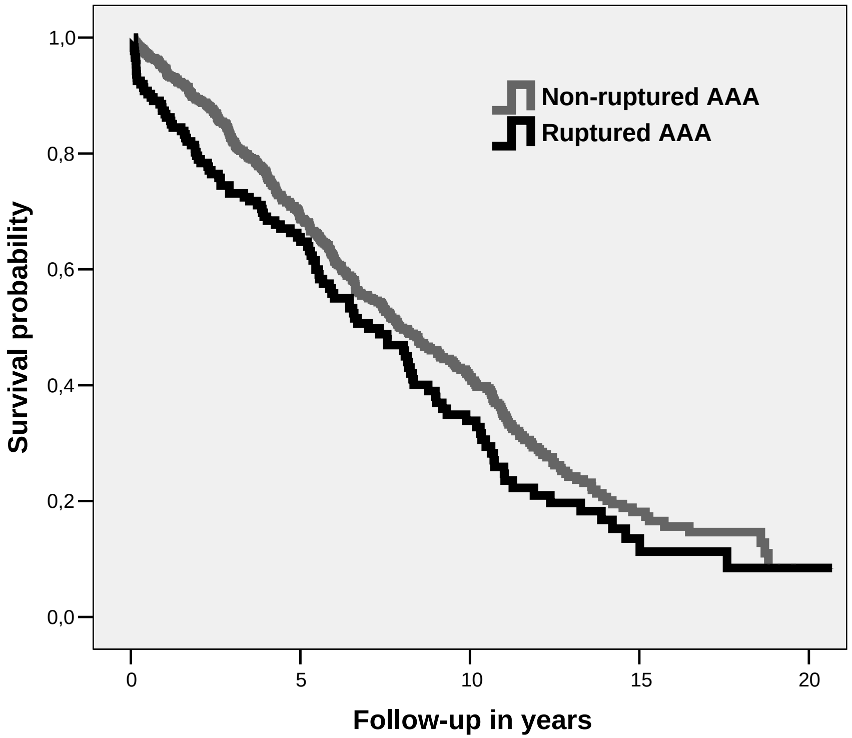

Operation time
Non-ruptured open AAA
Ruptured AAA
EVAR (non ruptured AAA)
Median operation time (min)
250
200
150
100
50
0
1983-87
1988-92
1993-97
1998-2002
5-years calendar periods
Anaesthesia time
Non-ruptured open AAA
Ruptured AAA
EVAR (non ruptured AAA)
Median anaesthesia time (min)
400
300
200
100
0
1983-87
1988-92
1993-97
1998-2002
5-years calendar periods

Figure 4



Non-ruptured AAA
Ruptured AAA
Survival probability
1,0
0,8
0,6
0,4
0,2
0,0
0
5
10
15
20
Follow-up in years