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Abdominal Aortic Aneurysm (AAA): The Decision Pathway in Ruptured and Non-Ruptured AAA

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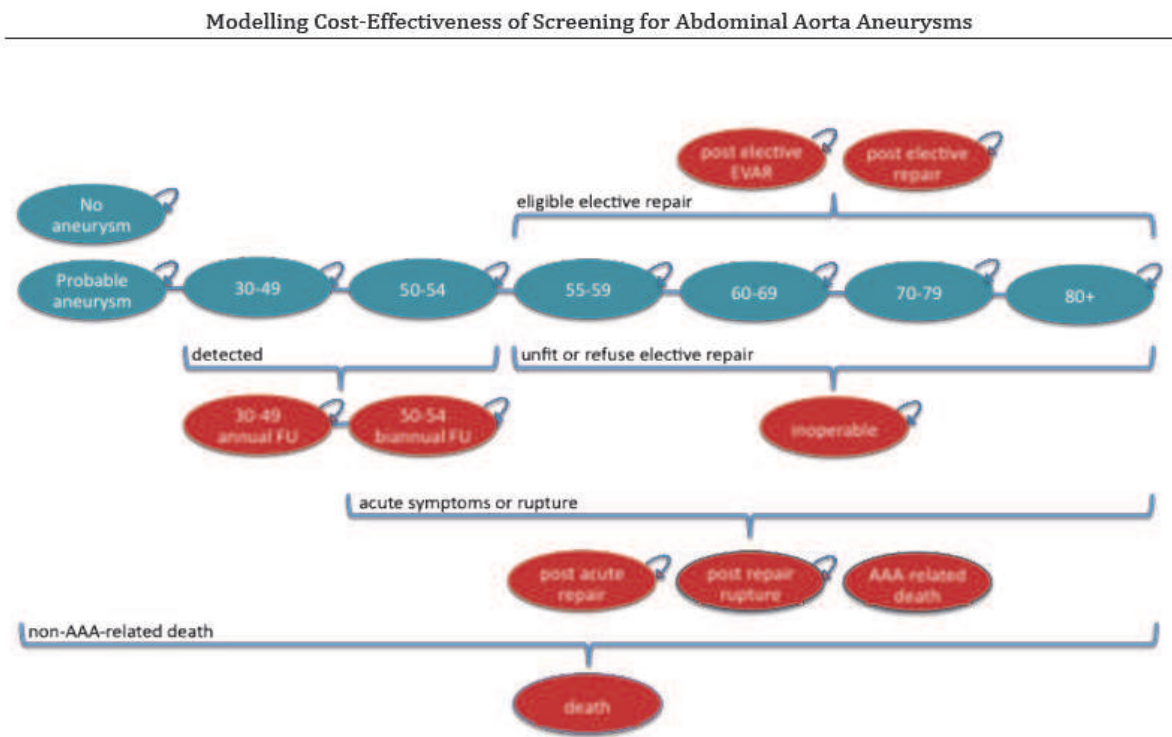
1. Introduction

Abdominal aortic aneurysm (AAA) derives from Greek ανευρυσμα (aneurusma), meaning widening, and can be defined as a permanent and irreversible dilatation of a vessel. In 1991 the Society for Vascular Surgery proposed as a criterion that the infra renal aorta diameter should be 1.5 times the expected normal diameter. In Europe it is defined as an abdominal aorta greater than 30mm. AAA is assumed to be prevalent in about 4% of males over the age of 65 although variation exists across countries and cause 1.3% of all deaths among men aged 65-85 years in developed countries (Best VA et al. 2000). Whether detected incidentally or by screening patients with an AAA ≥ 50 mm will be referred for surgical evaluation in Denmark. Patients detected with aneurysms below the threshold value for referral to surgery will be followed regularly and referred for surgery if their aneurysm grows or if they develop symptoms. Patients with symptomatic or ruptured AAA will be referred for acute surgery where, in some cases of rupture, the patient will die before reaching the hospital (vascular department). A proportion of patients will be unfit for surgery for anatomical or physiological reasons while another proportion will decline to have surgical / endovascular treatment. Until recent years, open surgery was primarily performed but the technique of endovascular aortic repair (EVAR) has now become a part of standard practice in many countries. The availability of EVAR is an important alternative for two reasons: it is less invasive and it provides a treatment opportunity for a proportion of these patients who are ineligible for open surgery. The natural disease history is progressive and may result in rupture with an associated mortality risk of up to 80%. If an AAA on the other hand is detected at an earlier, asymptomatic state there will be treatment modalities reducing the mortality risk dramatically. An increased awareness of the characteristics of AAA by first contact practitioners might reduce the risk of a fatal outcome with this disorder. In this chapter, we aim to provide and update review of the decision making in regard to elective and rupture treatment of AAA.

2. Indication for elective treatment

Although surgical treatment of non-rupture AAA relies on specific rare indications, such as distal embolisation, urethral compression, contain rupture, mycotic aneurysm, treatment of

intact AAA is essentially prophylactic and aimed at prevention of fatal rupture. The expected functional form of the relationship between risk of rupture and size, it would be appropriate to model relatively small size-intervals for larger aneurysms. Data availability on growth and rupture rates remain limited due to patients being repaired once their aneurysm reaches 55 mm, unless they are unfit or unwilling to receive surgical treatment. It was decided by Morkov model, that the disease process using starting states: definitely no AAA (0-25mm), probably no AAA (25-29mm), small or medium -sized AAA with essentially no risk of rupture (30-49mm), medium-sized AAA close to the iatrogenic threshold (50-54 mm) and four states of large AAAs above the iatrogenic threshold (55-59 mm., 60-69 mm., 70-79 mm. and 80+ mm.). Figure 1 shows the proposed model structure for which the underlying decision pathways and structural assumptions are detailed in the following. The choice of Markov model implies two overall assumptions. First, the so-calls Markova property states that individuals starting in a given state can be modelled in the same way. This means that the route to arriving in a state or time spend in a state has no influence on subsequent parameters. For example, when individuals arrive at acute open surgery their probability for a successful outcome is independent on whether symptoms arose from 30 mm or a 70 mm AAA. Second, the so-called stationary assumption states that parameters are time-homogeneous, and do not vary from one cycle to another. There are limited opportunities for relating assumption, which in the present context were taken advantage of to allow increasing mortality rates as population age.



Note: Blue ovals represent starting states. All numbers refer to abdominal diameter in millimetres. The model structure was applied equally for a scenario with and a scenario without screening EVAR= elective endovascular aortic repair. FU= follow up. AAA= Aortic abdominal aneurysm.

Fig. 1. Markov model for the course of abdominal aortic aneurysms

The starting states of AAAs above the threshold for eligibility for elective surgery share the same decision pathway, except that ≥ 80 mm cannot grow to the next state. If the aneurysm

is symptomatic they will be referred to acute surgery following a similar protocol as described for the 55-59 mm AAA whereas if non-symptomatic, they will either be detected and referred for elective surgery or remain undetected in the state (if no growth) or in the next disease state (If growth). The size of the abdominal aneurysm is a universally recognised factor to forecast rupture, and the general consensus is that patients with a large aneurysm >5.5 cm should undergo surgical treatment. The real controversy surrounds the management of small aneurysm and large aneurysm in unfit patients. Indication for surgical treatment is deduced from the estimated risk of rupture, the estimated risk of the surgical procedure, and the estimated life expectancy of the patient. Fig 2: shows proposed management plan for asymptomatic abdominal aortic aneurysms. To be most effective, it should be performed when the rupture risk is high compared with operative risk, in patients who will live long enough to enjoy the long term benefit. It is assumed the elective treatment should be offered without waiting time (since there is no option for rupture while waiting for surgery). In practice, elective surgical treatment might not offered on the same days as indicated but give a 30 -day treatment guarantee in the Danish health care system and discretion of surgeons to prioritize the most sever candidates first this seemed a justified assumption in order to moderate the complexity of model structure.

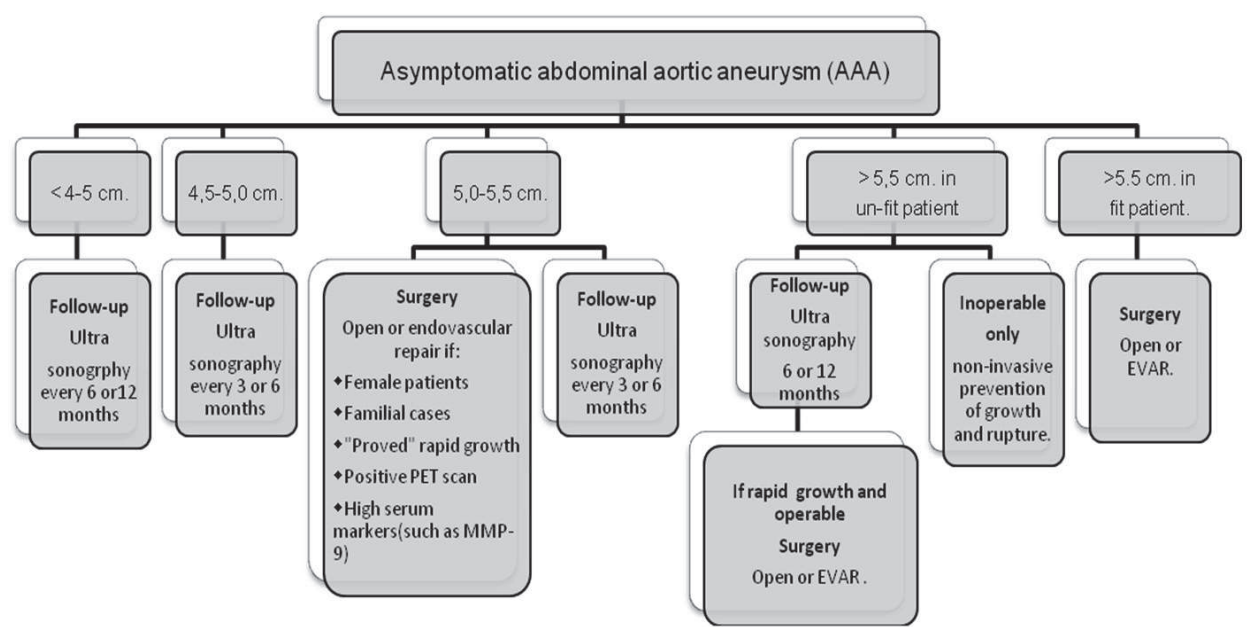


Fig. 2. proposed management of an asymptomatic abdominal aortic aneurysm. EVAR = endovascular repair of AAA.

2.1 Risk of elective aneurysm repair

Reported mortality rate related to elective AAA repair varies among hospitals and surgeons. Mean 30-days mortality rate has been reported between 1.1% and 7.0% (S. Shahidi et al. 2008). Randomized EVAR 1 showed the overall 30days mortality, regardless of the risk factors after open surgery and endovascular repair (EVAR) was 4.6% and 1.5%, respectively. In 2009 the overall 30-days mortality rate in Denmark was 2.7% out of 310 open surgeries and 2.1% out of 196 EVAR. (www.karbase.dk). Most deaths resulting from the repair occurred in the so called high-risk patient. Factors of increased operative risk are

renal failure, chronic obstructive pulmonary disease, and most importantly myocardial ischemia. In this matter, analysis of the EVAR 2 trial data performed by the EVAR investigators did not show a significant difference in either all-cause or aneurysm-related mortality. Thus, outcomes of the EVAR 2 trial have not settled the choice between EVAR and no treatment in this scenario to everyone's satisfaction. In patients with large AAAs who are fit for open surgery, EVAR offers an initial mortality advantage over open, with a persistent reduction in AAA-related death at 4 years. However, EVAR offers no overall survival benefit, is more costly, and requires more interventions and indefinite surveillance with only a brief QOL benefit. It may or may not offer a mortality benefit over non-operative management in patients with large AAAs who are unfit for open repair, but the statistical significance of this comparison is inconclusive. In relation to growth rate /year, there will always be a relative concentration of patients unfit for open surgery in the follow-up program. It is thus assume that the risk of rupture is not affected from that and the high risk patients individually should spotted in the matter of rupture risk/ year and the risk of open/ EVAR treatment, if this is technically possible and acceptable. Patients, who have a very low restricted life expectancy estimated (0-4) year, suggest treating by non-operative management.

3. Rupture abdominal aorta aneurysm, transition to AAA-related death

Related death is defined as consequence of rupture or as consequence of undergoing surgery if death occurs within 30 days postoperatively. A certain proportion of patients with rupture will not reach the hospital alive for emergency surgery. Most patients (92%) with a rupture who reach the vascular clinic alive have a rupture of the posterolateral wall into the retroperitoneal space. Banke A et al, 2008.

3.1 Risk of rupture

The UK small aneurysm Trial 1998 and the US Veterans Administration study led to similar findings despite a lower operative mortality 2.7% vs.5.8%). The conclusion was, infra abdominal aorta aneurysms smaller than 5.5 cm in diameter is safe, where as early surgery is not associated with improved long-term survival. Today it is accepted that AAA diameter is the best predictor of rupture risk. The variability of estimates of rupture risk for particular AAA diameters cited in the literature reflects differences in other factors besides maximal diameter which may vary considerably from series to series, and illustrates that other factors in addition to absolute size must be taken into account in each individual case. It is clear that there is a substantial increase in rupture risk as AAA diameter increase from 5 cm to 6 cm. (Nevit et al., 1989) reported no rupture during 5-years follow-up for AAA < 5 cm, but a 5% annual rupture risk for AAA > 5 cm at initial presentation. Similar estimates were obtained from the larger UK Small aneurysm Trial, where the annual rupture to be 0% (0-5%) for AAA < 4 cm. The long-term report from the UK small aneurysm has shown that the risk of rupture in women was nearly four times higher than in men. The studies of rapid expansion of AAA suggest the size of AAA is probably not the sole useful determinant for risk of rupture (Limet et al., 1991 & Gilmaker et al., 1991). Active investigations have been and still are being done to identify markers other than size that would predict a risk of rupture. The level of serum MMP-9 has been reported to be significantly higher in patients with AAA and also associated with the size expansion rate of these AAA (Sakalihasan et al., 1996).

Preliminary data obtained by PET Imaging of AAA have shown focal uptake of (¹⁸F-FDG) is regarded as a functional image of inflammatory response and thus as a potential non-invasive technique to identify unstable AAA that are prone to rupture Sakalihan et al, 2002. Probabilities of rupture were estimated from the literature. Estimates generated before year 2000 were considered to be outdated due to the introduction of medical treatment (Statin) in the beginning of 1990. After close examination of studies, the EVAR II was excluded since only patients fit for EVAR were included. Table 1 shows the estimated risk of rupture in AAA, as the function of AAA diameter size in centimetre.

AAA diameter size, (cm)	Rupture risk /year
4,0-4,9	0,5-5,0%
5,0-5,9	3-15 %
6,0-6,9	10-20 %
7,0-7,9	20-40 %
Over 8	30-50 %

Table 1. Estimated annual rupture risk in AAA.

The simple observation that not all AAAs rupture at a specific diameter indicates that other patient- or aneurysm-variable also effect rupture risk. The risk of rupture is also correlated with co-morbidities as age, lung disease COPD,blood pressure, cardial disease, diabetes. The probability for rupture among high risk patients who are inoperable is likely to be higher than the equivalent in aneurysm-size matched patients. No estimates of ruptures in the group of high risk patients were found to be available in literature. Important information concerning AAA rupture from the UK Small Aneurysm Trial was that patients with 4.0-5.5 cm AAAs , the relative risk of rupture was independently increased by female gender (3.0x), larger initial diameter (2.9x per cm.), current smoking (1,5x), age (1,3x per 4 years), worse COPD (0.6x per L ,FEV1), and higher mean arterial pressure (1.02x per mmHg). In addition to AAA size, many surgeons consider the ratio of diameter to the proximal normal aorta, a 5 cm. AAA in a patient with a 1.5 cm native aortic diameter may or may not to be at greater risk of rupture compared with the same size AAA in a patient with a native aortic of 2.5 cm. The validity of this concept, however has not been proven. The relative comparison between aortic diameter and the diameter of the third lumbar vertebra reported to increase the accuracy for predicting rupture risk, by adjusting for differences in body size (Ouriel et al., 1992). The improvement in prediction accuracy appears minimal, however, when compared with absolute AAA diameter. Although rapid AAA expansion is presumed to increase rupture risk, it is difficult to separate this effect from influence of expansion rate on absolute diameter, which alone could increase rupture risk.

3.2 Open emergency repair of AAA

The selection of patients with ruptured abdominal aortic aneurysms (RAAAs) for emergency repair can be a complex and emotionally charged process. Two possible broad approaches to patients with RAAA exist: an “all-comers” approach and a more “selective” approach. The all-comers approach offers surgical intervention in every patient, regardless of current status or presence of significant co morbidities. The selective approach would involve an assessment of operative risk predictors and co morbidities in an attempt to identify patients with an unrealistic expectation of a successful outcome. The epidemiology

of AAA is changing. (Best et al., 2000) reported a persistent increase in the incidence of emergency AAA with an associated increase in age-adjusted AAA mortality. The recorded incidence of RAAA varies from region to region in Denmark. The national incidence of operated AAA and RAAA per year has increased in the last 10 years in Denmark: That for operated elective AAA is 6 to 7/100,000 and that for RAAA is 3.5 to 6/100,000 populations (S. Shahidi et al., 2009).

Despite recent advances in anaesthetic, operative, and postoperative care, the high mortality figure has prompted many surgeons to question whether repairing RAAA should even be attempted in the subset of patients with poor physiological reserve. Although some decline has been reported over the years, the overall operative mortality is still in the range of 40-50% (Fig.3). Elderly patients have a restricted life expectancy. In Denmark in 2005-2006, life expectancy for males aged 60, 65, 70, 75, 80, and 85 years old was 18, 15.5, 11, 5, 6, and 4.8 years, respective (S. Shahidi et al., 2009). For patients who undergo AAA repair, the 5-year survival rate is reduced compared to age and matched individuals (60-65%) (Barlow AP et al., 1989). Excess mortality in this patient group is substantially attributable to associated comorbidities, particularly coronary artery disease. In order to make this difficult decision more objective, a number of scoring systems have been constructed; however, none of them focuses on practical scores, which can be calculated preoperatively in an elderly surgical patient with RAAA. Is it pointless to operate on an elderly patient with RAAA? Can we exclude such patients from RAAA treatment? What should we do with elderly patients with RAAA?

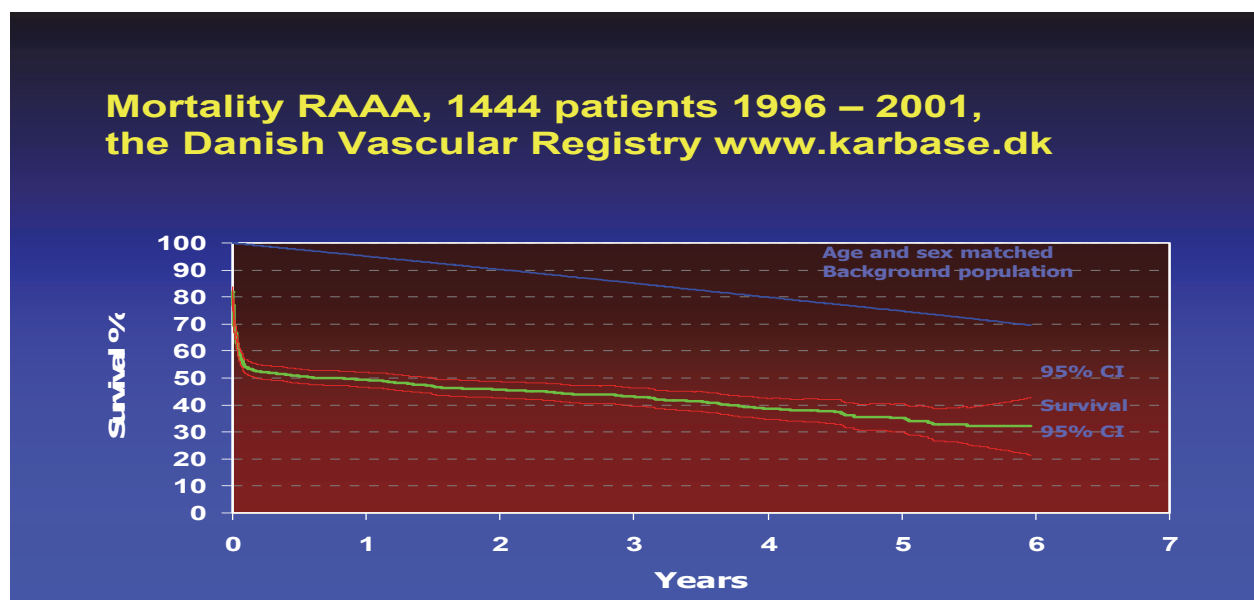


Fig. 3. Overall operative mortality after RAAA compared to background population, shows 40-50% survival reduction in the first 30 days after rupture (www.karbase.dk).

However, repair of RAAA in the elderly generally requires a careful assessment of life expectancy and of the impact of repair-related complications in this specific high-risk subset of patients. It may be still question, if would repair really be the best solution for the elderly patient? Should the patient be palliated? Would the resources we need to use be correctly addressed? These rhetorical questions and issues pose an increasing challenge and discussion for vascular-surgeons. In this respect, ethical problems and cost analysis can be

important components in the decision-making process. Some might claim that the health economy aspects are hardly relevant or that health economy has nothing to do with decision-making concerning the individual patient (at least not yet). Furthermore, some are of the opinion that the cost incurred during prolonged intensive treatment of elderly patients is substantial and that these resources, ideally, should not be wasted on futile endeavours. Currently, as clinicians are increasingly required to accept fiscal autonomy and budgetary responsibility, it is important that the use of health-care resources benefits not only the individual patient but also the wider group of all patients attempting to gain access to health care. This managerial role involves an increasing awareness of cost restraints within the health service, an awareness of the pressure to rationalize limited resources, and the need for awareness both in Denmark and worldwide of the realistic outcomes of a proposed treatment option.

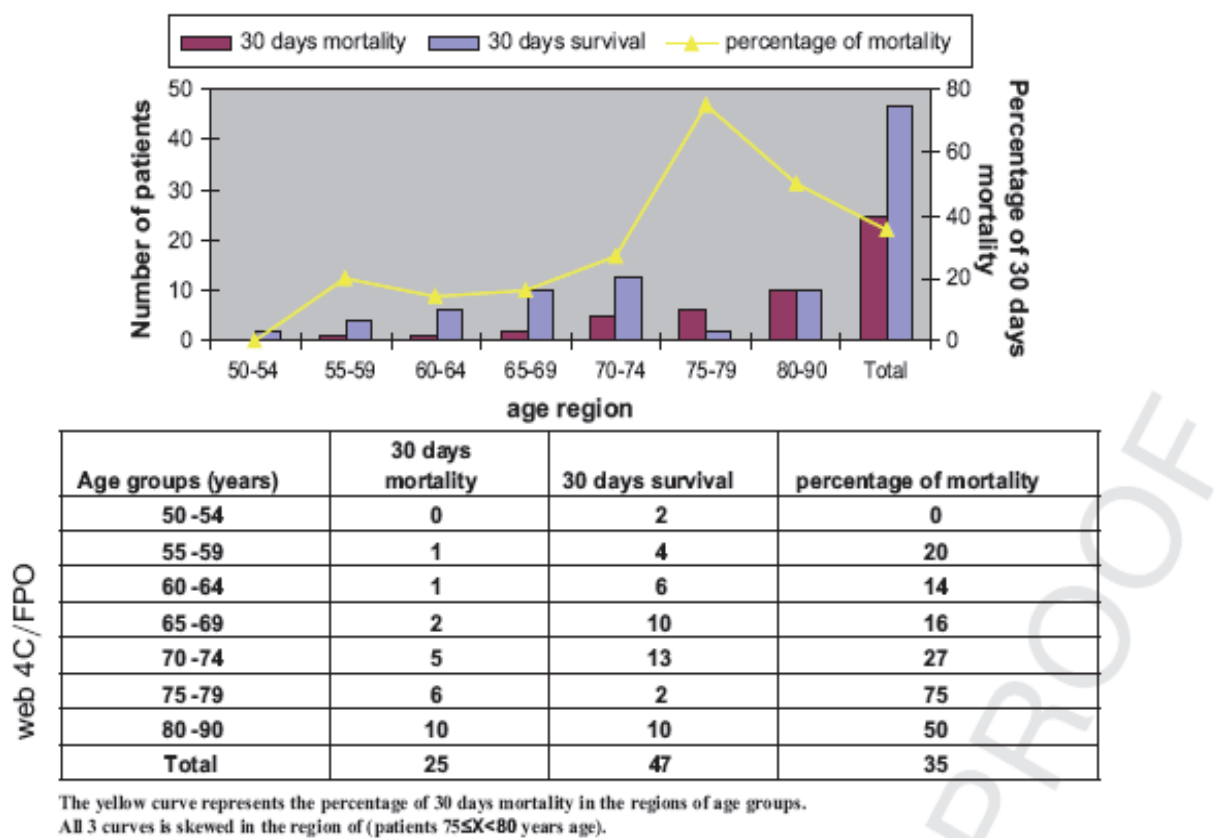


Fig. 4. Thirty-day mortality and survival after open repair of RAAA in the regions of age groups¹: S. Shahidi et al, 2009.

In 2005, the policy of our department was to operate on all patients with an RAAA who reached the hospital alive, who did not refuse surgery, and who did not have a severe terminal malignancy. In some institutions, patients are selected for repair after consideration of age, presentation, and medical co morbidities. A recent survey showed that 97% of U.K. vascular surgeons practice a selective approach (Hewin DF et al., 1998). Many reports have attempted to identify independent predictors for mortality, but there is no ideal scoring system for preoperative assessment of elderly patients needing emergency RAAA surgery (Al Omran et al, 2004, S. Shahidi et al., 2009, 2010). Some preoperative scoring systems

provide approximate estimates of mortality risk, but none has proved sufficiently specific for use on elderly individuals. Among the 72 cases of infra- and juxtarenal open RAAA repair, 30-day mortality was markedly skewed around a median age in the region of 75-79 years. The number of procedures in the different age groups according to 30-day mortality is presented in Figure 3. 2009. Out of 28 elderly patients (39%), eight (11%) were 75-80 years of age and 20 (28%) were aged 80 or more. The 30-day mortality was 75% for patients 75-80 years of age and 50% for patients aged 80 years or more. The 30-day mortality rates for patients in the elderly group was 16 (57%, CI 48-72%), significantly higher than the mortality rate of 9 (20%, CI 12- 33%) in the younger group ($p < 0.001$) (Table 2). The significant risk factors identified by univariate analysis were then used in a multivariate analysis by means of simple logistic regression with death as the outcome to predict mortality. The logistic regression analysis was repeated to find significant independent risk factors in the elderly compared to the younger groups. As illustrated in Table 2, age ≥ 75 and creatinine level ≥ 0.150 mmol/L were the only significant ($p < 0.05$) risk factors in the present study.

Multivariate analysis logistic regression of 30-day mortality among RAAAs ($n = 72$)

Variable	Probability	Odds ratio	95% CI	<i>p</i>
Creatinine ≥ 0.150 mmol/L	0.0875	7	1.85-28.78	0.0005*
Age ≥ 75 years	0.0799	3.88	1.62-17.08	0.0014*
Preoperative BP < 90 mm Hg	0.0531	1.133	0.127-1.107	0.051

* $p < 0.05$, significant.

Table 2. Multivariate analysis of 30 days mortality from (S. Shahidi et al; 2009).

In this study the age range for 30-day mortality was a markedly skewed distribution around a median age in the region of 75-80 years (Fig. 1). The ROC analysis in our series showed that the age of 75 years gave the greatest area under the curve for predicting 30-day death postoperatively (a cut-off age). Of course, the sample size is small and this would be a bias; but with the above studies and the life expectancy of Danish males in mind, our study suggests that a male patient aged 75 years or more with an RAAA should be considered elderly. There are some other risk score systems. In another study, we compared of preoperative levels of Base deficit and Lactate in predicting outcome in patients with open repair after RAAA (S. Shahidi et al., 2010). From January 2006 to December 2008, the medical records of 47 patients with RAAA were reviewed. Of the 47 patients enrolled in the study, 44 were men and 3 were women, with a median age of 71 (CI: 69-73), at admission. Patient's demographics and underlying co-morbidities are listed in Table 3. Twenty-five (53%) patients died within 30 days in the per-operative period. Altogether, there were twelve (26%) on-table deaths; five (11%) patients died within 24 hours after surgery; 8 (17%) patients died of multi-organ failure. Survivors had a median age of 70(range 40-83), which is significantly younger than non-survivors 75(range 59-85) ($p=0.009$). Pre-operative lactate ($p=0.011$), pre-operative base deficit ($p<0.001$), measured blood loss ($p=0.002$) are significant higher in non-survivors compared with survivors. These data suggest that pre-operative base deficit is a valuable marker better than pre-operative lactate for the identification of the per-operative death of patients with ruptured AAA. A threshold of level of -4.0 mmol/L of pre-operative base deficit had the highest combined sensitivity and specificity for the identification of per-operative death

after repair of ruptured AAA. The sensitivity and specificity of pre-operative base deficit <-4 mmol/L was 80.0% and 86.3%, respectively.

Receiver-operating-characteristic (ROC) curves were constructed to illustrate various cut-off values of pre-operative lactate, and base deficit. The mean ± SE area under the receiver-operating-characteristic curve for pre-operative base deficit was 0.83±0.06 (95% confidence interval 0.71 to 0.95, $p<0.001$) among non-survivors. Pre-operative lactate level had a mean area under the curve of 0.72±0.08 (95% confidence interval 0.57 to 0.87, $p=0.011$) among non-survivors. A cut-off value of -4 mmol/L of pre-operative base deficit has 80.0% sensitivity and 86.3% specificity respectively

	Media(range) Survivors	Media(range) Non-survivors	P*
Age	69,5(26-83)	75(56-89)	0.009
Lowest preoperative MAP (mmhg)	104(61-147)	70(0-153)	.029
Pre-operative Hb(g/dL)	9.9(6.6-14.0)	7.3(4.6-12.0)	.001
Pre-operative Cr.mmol/L	150(80-270)	180 (80-390)	.001
Pre-operative Lactat mmol/L	3.7(0.5-15.0)	6.5(1.0-17.0)	.011
Pre-operative base deficit mmol/L	-0.6(-11.9-6.2)	-11(-21.8-3.3)	<.001
Lowest intra-operative MAP (mmhg)	70(0-87)	40(0-82)	<.001
Intra-operative blood loss (L)	3.1(0.6-11)	6.8(1-20)	.002
Intra-operative temperature(Intra blader)	≥ 35 ° c	≤34 ° c	.001
intra-operative blood transfusion (Units)	21(8-66)	28(8-70)	NS

Table 3. Clinical variables in survivors and no survivors after open RAAA repair.

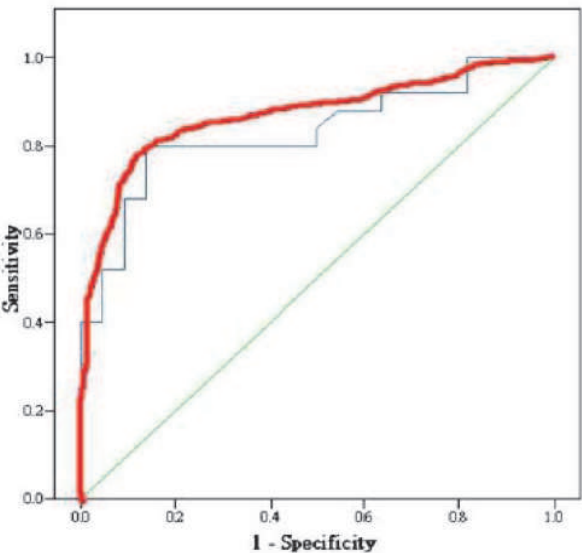


Fig. 4. ROC analysys curve for base difficiet in our study.

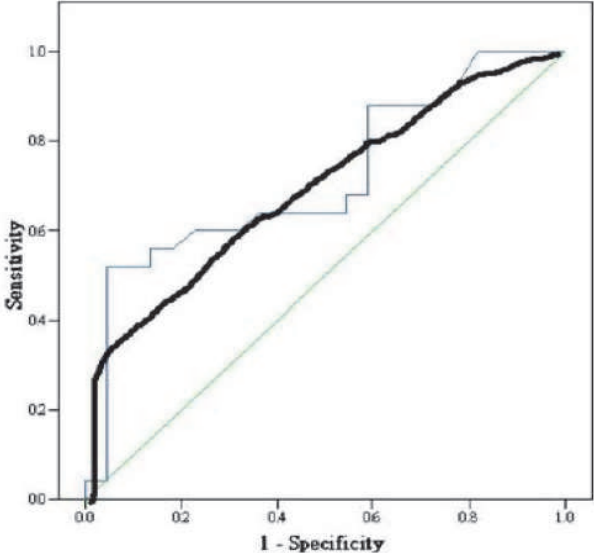


Fig. 5. Roc analysis curve for lactat in our study

Fig. 4 & 5. Receiver operating characteristic curves of preoperative lactate (black), and base deficit (red).

4. Health economic finance

The financing of Danish hospitals is through the national Diagnostic Related Group (DRG system). DRG is classified by diagnosis and surgical procedure according to this system and gives a value estimated by Danish health authorities. Since the majority of the procedures were complicated, the DRG with recorded complications was used. Based on these DRG values, the cost of each of the 30 days gained from surgical repair in these elderly patients could be estimated. The DRG value for the year 2005 was used for all patients. DRG is the average expenses, which depends on two parameters of the ICD-9 diagnosis, e.g., I.713 (RAAA), and the treatment, e.g., KPDG10 (operation for AAA). The average estimated cost of in-hospital treatment of RAAA was €15,350 (DRG) in 2005 in Denmark. In 2005, the Danish health authorities estimated the average cost of an operation for RAAA to be €15,350 DRG compared to an elective AAA, which is €8,500 DRG. Concerning the age 75 years, our data show that the respective risk difference (RD) is approximately 0.38 (0.157-0.575), with an estimated NNT of 2.0 (1.74-6.34) (S. Shahidi et al., 2009).

5. Discussion

Decision-making in regard to elective repair of AAA requires careful assessment of factors that influence rupture risk, operative mortality and life expectancy. Individualizes consideration of these factors in each patient is essential, and role of patient preference is of increasing importance. The surgeon should be very aware that the elective treatment of AAA in every case and in any time is only a prophylactic treatment. It is not possible or appropriate to recommend a single threshold diameter for intervention which can be generalized to all patients. Based upon the best available current evidence, 5.5 cm is the best threshold for repair in an "average" patient. However, subsets of younger, good-risk patients or aneurysms at higher rupture risk may be identified in whom repair at smaller sizes is justified. I do believe that delaying in repair until larger diameter may be best for older, higher-risk patients, especially if endovascular repair is not possible. Intervention at diameter < 5.5 cm appears indicated in women with AAA and maybe in patients with rapid AAAs expansion. If a patient has suitable anatomy, endovascular repair should be considered, and it is most advantageous for older, higher-risk patients, who has acceptable life expectancy. The patient with a very low life expectancy should not undergo an invasive prophylactic repair. There is evidence for EVAR clearly reduced perioperative mortality, morbidity and recovery time, however, there is a higher reintervention rate, increased surveillance burden, and a small but ongoing risk of AAA rupture. In my knowledge there is no justification at present for different indications for EVAR, such as earlier treatment of smaller AAA. We are still waiting for long-term outcome of endoluminal repair is better defined and results of randomized trials available, the choice between EVAR and Open repair will continue heavily on patient preference and information.

In the matter of RAAA and emergency repair of RAAA, there are many reports, as the report from the Mayo Clinic showed that advanced age, high Acute Physiology and Chronic Health Evaluation (APACHE II) score, low initial hematocrite, and preoperative cardiac arrest increased mortality rates (Goffi et al., 1999). The APACHE II is commonly used to assess surgical patients in the ICU, where it was designed to predict outcome, but has seldom been used in preoperative assessment. The APACHE II scores appear to predict

outcome equally well when the age points are omitted. Goffi concluded that fit elderly persons should not be denied an emergency operation because of their age alone. (Hardman et al., 1996) reviewed 154 patients and identified five independent preoperative risk factors that were associated with mortality: age >76 years, an ischemia electroencephalogram, Hb <9 g/dL, creatinine >0.19 mmol/L, and loss of consciousness. They also reported that all patients who presented three or more variables died. In addition, (Johnston et al., 1994) found that hypotensive patients with raised creatinine had only a 20% chance of survival. The Glasgow Aneurysm Score (GAS), first described in 1994, calculated a risk of mortality with RAAA using age in years: +17 for the presence of shock, +7 for myocardial disease, +10 for cerebrovasculare disease, and +14 for renal disease (Sammy ak et al.). All of these findings strongly suggest that mortality is determined by the severity of physiological insult and the patient's premorbid physiological reserve. Despite the findings of our studies and other studies, there is still no consensus on how to use these preoperative variables. While these clinical variables may prove useful, they must be interpreted with caution and should only act as an adjunct to clinical decision-making. A ruptured aneurysm is lethal in almost every case, unless the patient is operated successfully (Olsen P et al., 1991). That is why the scoring system should be able to differentiate those elderly patients who have no chance of survival from those who are likely to benefit from surgery (S. Shahidi et al., 2009 and 2010). The estimated cost per life after 30 days postoperatively was €40,409 (DRG) for the elderly patient in our cohort in 2005 compared to €18,880 (DRG) in the younger group. This can be compared to the cost per year of life gained by haemodialysis, which is estimated to be at least €50,000 (Winkel M. et al., 1999). Regarding the health economic aspect in RAAA patients, we found only one study. An interesting Norwegian study showed the total survival time of octogenarians treated for RAAA. Over a 20-year period, 53 patients aged 80 years or older were operated for RAAA. The survival time was estimated and related to DRG values in order to estimate the cost of each year of life gained by operating on this type of patient (Aune et al., 2004). The authors concluded that the operative mortality for patients aged >80 years with RAAA is high (47%) but the price of each gained year of life is relatively low. The estimated cost per gained year of life was € 6,817. The accurate cost of each operation obviously varies and is difficult to calculate. That is why we have based our calculation on the DRG cost. There is some evidence of a significant reduction in mortality from AAA in men aged 65-79 years who undergo ultrasound screening. The cost-effectiveness may be acceptable but needs further expert analysis (Mass study 2002). A Cost effectiveness analysis based on a probabilistic, enhanced economic decision analytical model from screening to death (MTV report) from Denmark (showed the estimated costs per quality adjusted life year (QALY) gained discounted at 3% per year over a lifetime for costs and QALYs was £43 485 (£54 852; £71 160). At a willingness to pay threshold of £30 000 the probability of screening for abdominal aortic aneurysm being cost effective was less than 30%. One way sensitivity analyses showed the incremental cost effectiveness ratio varying from £32 640 to £66 001 per QALY. Ehlers concluded screening for abdominal aortic aneurysm does not seem to be cost effective. Further research is needed on long term quality of life outcomes and costs (Ehlers et al., 2008). These findings still need careful consideration in judging whether a co-coordinated population-based screening program should be introduced. The screening program has been implemented in United Kingdom. In Denmark we are waiting for further expert analysis and approval from the Danish health authorities. The screening program would be discussed in other chapters. Open repair is still the predominant procedure for RAAA. Until today, there has been no high-quality evidence to

support the use of (EVAR) in the treatment of RAAA. However, evidence from prospective controlled studies without randomization, prospective studies, and retrospective case series suggests that EVAR is feasible in selected patients, with outcomes comparable to best conventional open surgical repair for the treatment of RAAA (AJAX trial still going on). The numbers of EVAR procedures for this group are small in Europe. The second VASCUNET data-base report from 2008 for 10 year operative outcome of more than 33.000 patients with aortic aneurysms in six countries, Denmark (DK), England (UK), New Zealand (NZ), Australia (AST), Sweden (SW) and Switzerland (SWZ), with participating of 202 hospitals, showed a much less use of EVAR in RAAA in these countries. The percentage of operation type according RAAA and EVAR in these six countries until 2009 was DK=1, UK=4, NZ= 7, SW= 22, AST=8 and SWZ=21 of all ruptures (S. Shahidi et al., 2009). The promising results for EVAR of ruptured abdominal aneurysms may have the potential to significantly lower the mortality in all RAAA patients. That is why the author suggest, all elderly high risk patients, patient with preoperative renal dysfunction and pre-operative base deficit < -4 mmol/L should be selected to EVAR, if this is technically possible. Had we chosen not to operate on elderly patients with preoperative serum creatinine 0.150 mmol/L, or elderly patients with a basis deficit -4.0 mol/ l, at least eleven patients would have been denied a life-saving operation. All of these eleven patients were successfully discharged from hospital (S. Shahidi et al., 2009 & 2010; Banke A., 2008).

6. Conclusion and future

The arbitrary setting of a single threshold diameter for elective AAA repair applicable to all patients is not appropriate, as the decision for repair must be individualized in each case. The most important thing in individual decision-making of this elective prophylactic treatment is the estimated risk of rupture, the estimated risk of the surgical procedure, and the estimated life expectancy of the individual case, and giving the competence to the out-patients for making decision along with the surgeon.

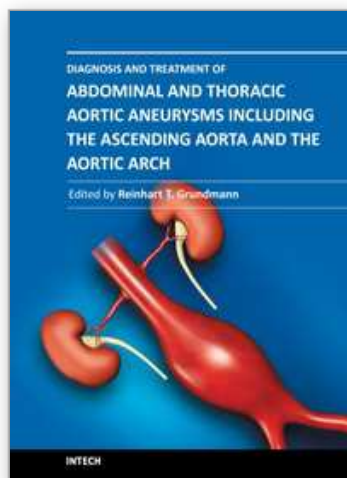
The ideal treatment of RAAA is prevention or to increase the probability of reaching hospital alive in case of rupture. In our experience, after 1-year follow-up, open repair has been life-saving in 77% of patients younger than 75 years, with a low price estimated at € 18,880, and surgical repair has been life-saving in 33% of patients aged 75 years and older at a relatively low price for each life, estimated at € 40,409. The first goal in abdominal aortic aneurysm still is the prevention of rupture; hopefully the next aim in the future will be the prevention of abdominal aortic growth.

7. References

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Diagnosis and Treatment of Abdominal and Thoracic Aortic Aneurysms Including the Ascending Aorta and the Aortic Arch

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This book considers diagnosis and treatment of abdominal and thoracic aortic aneurysms. It addresses vascular and cardiothoracic surgeons and interventional radiologists, but also anyone engaged in vascular medicine. The book focuses amongst other things on operations in the ascending aorta and the aortic arch. Surgical procedures in this area have received increasing attention in the last few years and have been subjected to several modifications. Especially the development of interventional radiological endovascular techniques that reduce the invasive nature of surgery as well as complication rates led to rapid advancements. Thoracoabdominal aortic aneurysm (TAAA) repair still remains a challenging operation since it necessitates extended exposure of the aorta and reimplantation of the vital aortic branches. Among possible postoperative complications, spinal cord injury (SCI) seems one of the most formidable morbidities. Strategies for TAAA repair and the best and most reasonable approach to prevent SCI after TAAA repair are presented.

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