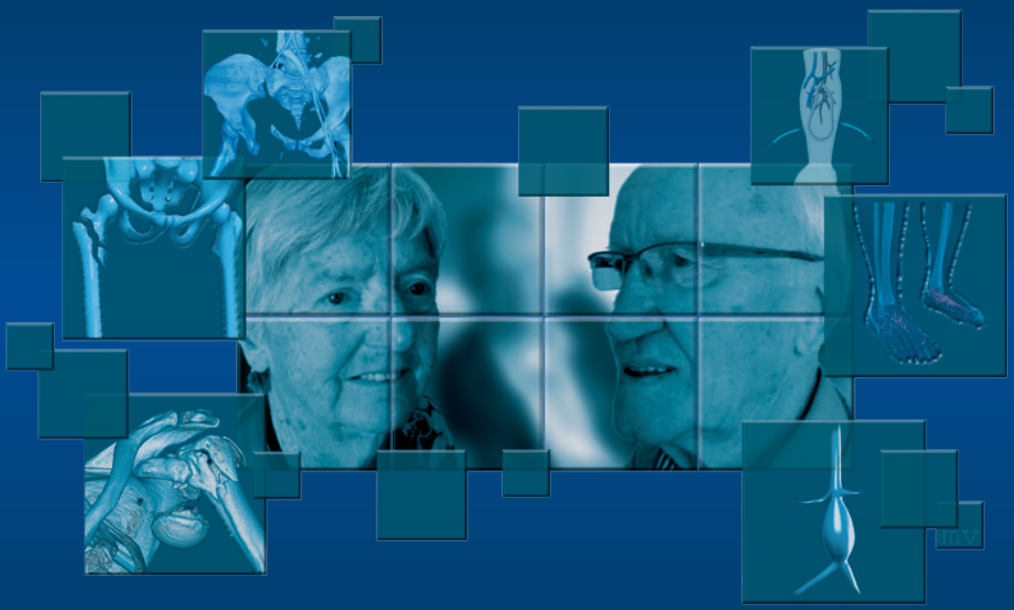
SURGERY IN THE ELDERLY:
DOES AGE MATTER?



Kevin de Leur

Surgery in the Elderly: Does age matter?

Kevin de Leur

Surgery in the elderly: does age matter?
PhD thesis, Erasmus University Rotterdam, with summary in Dutch
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SURGERY IN THE ELDERLY: DOES AGE MATTER?

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CONTENTS

Chapter 1	Introduction and outline of this thesis	7
PART I	***Outcomes of various aspects of vascular surgery in elderly patients***	
Chapter 2	Vascular access outcome in the elderly dialysis patient in combination with the Quality of Life *Vascular and Endovascular Surgery. 2013 Aug;47(6):444-8.*	19
Chapter 3	Treatment for critical lower limb ischemia in elderly patients *World Journal of Surgery. 2012 Dec;36(12):2937-43.*	33
Chapter 4	Outcome of elective treatment of abdominal aortic aneurysm in elderly patients *International Journal of Surgery. 2015 Mar;15:117-23.*	47
PART II	***Outcomes of various aspects of orthopaedic trauma surgery in elderly patients***	
Chapter 5	Increasing rates of pelvic fractures among older adults, The Netherlands, 1986-2011 *Age and Ageing 2014 Sep;43(5):648-53.*	71
Chapter 6	Proximal fractures of the humerus in patients older than 75 years of age: Should we consider operative treatment? *Journal of Orthopaedics and Traumatology. 2014 Jun;15(2):111-5.*	*83*
Chapter 7	Outcome after osteosynthesis of hip fractures in nonagenarians *Clinical Interventions in Aging. 2014 Dec;9:41-9*	93
Chapter 8	General discussion and future perspectives	107
Chapter 9	Samenvatting, algemene discussie en toekomstperspectieven	115
Chapter 10	List of publications	127
	List of abbreviations	129
	Dankwoord	131
	Curriculum vitae	135

Chapter 1

Introduction and outline of this thesis

INTRODUCTION

The population of older adults, aged 65 years and older, is rapidly increasing worldwide.[1] A growing population of older adults in number and an increasing life expectancy of individuals accounts for this change in societal balance.

Figure 1 shows the distribution of age in the Dutch population in the years 1990, 2014 and 2040.[2] It makes clear nowadays the Dutch population has more people in the age of 70 and 80 years as compared to 1990.

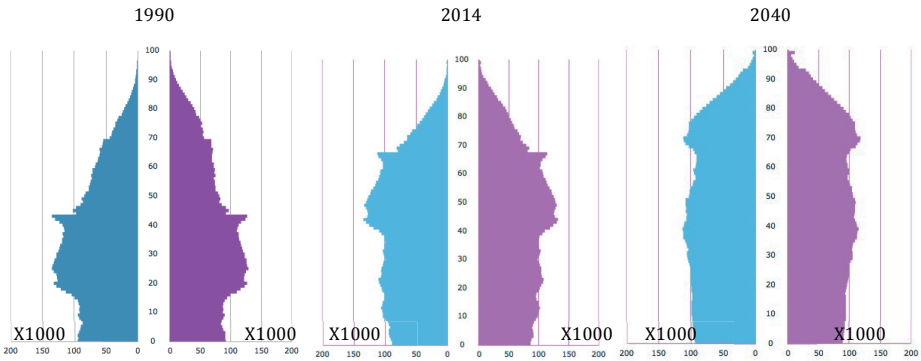

Figure 1. Population pyramid of age distribution in the Netherlands in 1990, 2014 and 2040 respectively.

The bulge in this pyramid at 40 to 70 years will result in an obvious growth of the elderly in the next decades. Another way to clarify the demographic shift in the elderly population in the Netherlands is demonstrated in Figure 2.[2] The population of people aged 60-69 years remains relatively stable over the coming decades. However, there is a significant increase in people aged 70-79 years and 80 years and over.

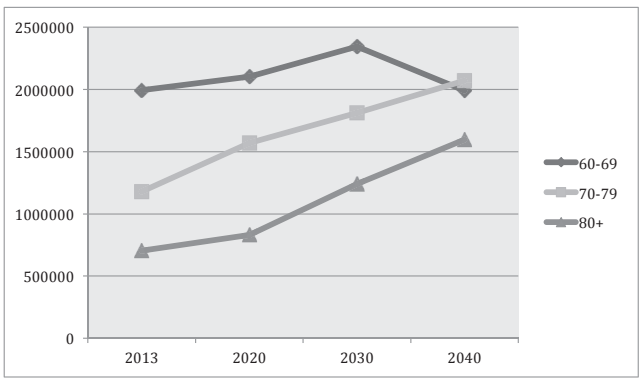

Figure 2. Demographic shift in elderly population in the Netherlands.

The consequences of these changes in age of population are enormous and cannot be overstressed. It will result in different social, economic and health-care related issues. So for example there will be an alteration in the ratio of working people to those depended and retired. Healthcare costs will increase due to a higher care demand of the elderly population. [3] A relevant issue will be the attitude in medical decision-making related to the group of very old patients. To understand some potential healthcare problems that these changes entail, this thesis examined various surgical treatments and specific disorders of the elderly patient.

Nowadays, elderly patients are defined as patients aged 65 years and older.[4] In perspective of the fact that half of the girls born in 2013 are expected to reach the age of 100 years, it seems necessary to adapt this definition as perspectives are changing. It remains difficult to determine the age-threshold for the definition of "older people", but shifting this definition to 75 or 80 years and older seems justified.

To date, little is known about the outcome of surgical interventions in older people with respect to the quality of life and functional recovery. The success of surgical treatments in younger people may not be similar to the outcome of the same interventions in elderly people, Therefore, it remains to be determined whether the outcome of larger surgical interventions for people aged above 65 years may be extrapolated to people aged above 75.

The prevalence of various operations for several diseases in the elderly is shown in table 1. These percentages are derived from the Amphia hospital, Breda, the Netherlands.

Table 1. Prevalence of operations (%) for several disorders according different age groups in the Amphia hospital, Breda, the Netherlands

	Age Groups		
	<70	*70-79*	*80+*
Operation			
Humerus fracture	56 %	17 %	27 %
Femur fracture	28 %	22 %	50 %
Critical limb ischemia	40 %	23 %	37 %
AAA	26 %	60 %	14 %

Data are presented as percentages
AAA=Abdominal aorta aneurysm

To determine the outcome of vascular and orthopaedic trauma surgery in the elderly, we initiated a number of studies focusing on vascular and trauma-related diseases. For vascular surgery we examined the outcome of different treatment options (e.g. endovascular vs. reconstructive surgery vs. conservative treatment) in different age groups with special attention for the results of conservative treatment. In critical limb ischemia, conservative treatment

was defined as adequate pain relief and wound care. Conservative treatment for abdominal aortic aneurysm implicated a wait and see policy without any surgical intervention.

Other studies were focused on traumatic lesions and the outcome of orthopaedic trauma surgery to determine the effect of treatment in the elderly population with regard tot the quality of life as well as functional result. Due to the increased life expectancy age-related problems are rising, including osteoporosis and falls.[5,6] Falls are the main cause of injuries among older adults, and leading to a high healthcare demand. It is open for discussion whether the benefits of recovery outweigh the high perioperative risks and the loss of daily function in the process of recovery and the length of rehabilitation. Quality of life is an increasingly important indicator of treatment in elderly persons. Knowledge of the functional outcome as well as the effect of the intervention on daily life, in many cases already limited due to age-related problems may help in making the best choice in the management of these patients, considering the quality of life, health care costs and chance to maintain an independent lifestyle.

The goal of this thesis was to evaluate the health outcome measurements related to the surgical approach of vascular and orthopaedic trauma related diseases in older patients and to compare with younger patients.

OUTLINE OF THIS THESIS

The aim of this thesis was to analyse health outcome measurements of surgical and conservative treatment for several vascular and orthopaedic trauma related diseases in the elderly patients. The thesis is outlined in two parts.

The first three studies describe the outcome of various aspects of vascular surgery in elderly patients. In **chapter 2**, we examine the preference for the anatomical location of arteriovenous fistulae in patients 75 years or older with primary and secondary outcome measurements, defined as patency rates and mortality, respectively. In addition, a secondary outcome studied was the quality of life, an important component in dialysis patients influenced by many parameters. **Chapter 3** presents the outcome of surgical interventions for critical limb ischemia in patients in different age groups (70-79 years and 80 years or older). Critical limb ischemia results in high morbidity and mortality and gives an increased risk of amputation when left untreated. To date, treatment of critical limb ischemia has shifted towards the increasing use endovascular procedures, but results of various vascular therapies in especially the elderly are yet unknown. In the elderly the benefits of revascularization might be limited due to more comorbidities and short life expectancy. Therefore, optimal management of critical limb ischemia in the elderly is not straightforward and various treatment options are open for discussion. We compared different treatment options (conservative, endovascular, reconstructive surgery and amputation) and described survival, re-intervention rate and major amputation rate. **Chapter 4** describes the results of our study on the outcome of different surgical precedures to treat an abdominal aortic aneurysm (AAA) in patients aged 70 years and older. Optimal management of AAA in the elderly results in a risk assessment of their age, comorbidity, AAA size-related risk of rupture, functional and social status. This chapter includes a review of the literature concerning treatment of AAA in elderly patients.

The second part evaluates orthopaedic trauma surgery in elderly patients. Osteoporosis, falls and fractures are major public health issues among elderly. Pelvic fractures are associated with a serious morbidity and hospitalization rate. We therefore performed a study (**chapter 5)** to determine trends in incidence and age-specific rates of pelvic fracture related hospitalizations amongst elderly in the Netherlands. In **Chapter 6** the results are described of an observational study analysing the outcome of operatively treated elderly patients (> 75 years) with a fracture of the proximal humerus. The incidence of these fractures is increasing along with the increasing elderly population. With the advent of more advanced implants and improved surgical techniques, surgical interventions for these fractures are gaining more acceptances. Possible advantages include faster mobilization, less pain and better functional outcome. This is particularly true for younger patients.[7] However, the outcome of surgical treatment of these fractures in the elderly is not known yet. One of the most common fractures in the elderly is the proximal femoral fracture. **Chapter 7** reports on the functional outcome and mortality rates after osteosynthesis of hip fractures in extremely old (≥90 years)

patients. This chapter focuses especially on the extremely elderly and discusses the question if a parameter or score can be defined that predicts the outcome of treatment within this population.

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PART I

OUTCOMES OF VARIOUS ASPECTS OF VASCULAR SURGERY IN ELDERLY PATIENTS

Chapter 2

Vascular access outcome in the elderly dialysis patient in combination with the Quality of Life

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Vascular and Endovascular Surgery. 2013 Aug;47(6):444-8.

ABSTRACT

Purpose: We performed a retrospective study on hemodialysis fistulae in patients aged 75 years or older.

Methods: Dialysis records of 2 hospitals were searched for patients of 75 years or older who had primary autologous radiocephalic arteriovenous fistulae (RCAVFs) and brachiocephalic arteriovenous fistulae (BCAVFs). Outcome measures were primary, primary-assisted and secondary patency rates. Also, quality of life (QoL) was measured.

Results: A total of 107 fistulae were placed in 90 patients; 65 (61%) RCAVFs and 42 (39%) BCAVFs were created. The primary patency rate (p=0,026) and the primary-assisted patency rate (p=0,016) of BCAVFs were significantly higher than that of RCAVFs. Secondary patency rates at 1 year (p=0,01) and 2 years (p=0,035) were higher in BCAVFs than in RCAVFs.

Conclusions: The BCAVFs give significantly higher primary and primary-assisted patency rates and also significantly higher secondary patency rates at 1 and 2 years. Therefore, we suggest the placement of elbow fistulae in the elderly patients. The QoL was surprisingly high in this population despite a high mortality rate.

INTRODUCTION

The Dialysis Outcomes Quality Initiative (DOQI) recommends radiocephalic arteriovenous fistulae (RCAVFs) before brachiocephalic arteriovenous fistulae (BCAVFs) in all dialysis patients needing hemodialysis (HD). When the placement of arteriovenous fistulae (AVFs) is indicated for patients requiring HD, the primary creation site according to the DOQI should be in the nondominant limb and then in order of preference, radiocephalic, brachiocephalic and brachiobasillic.[1-3] There are several factors influencing the patency of AVFs such as smoking, obesity, diabetes, gender, and ethnicity and age.[1] Several studies reported mixed results in comparison to outcomes in RCAVFs and BCAVFs in elderly patients.[3,4]

In elderly patients, in need of HD, the patency rates of different types of AVFs can be useful to make a decision about which type of AVF should be used. Weale et al described equivalent outcomes in RCAVFs and BCAVFs in patients ≥ 80 years.[3] The RCAVFs have a high functional failure rate compared to BCAVFs.[5] However, the RCAVFs are preferred to BCAVFs because future access site options should be saved in the HD population. In elderly patients with lower life expectancy, a fistula with higher primary patency rate and less reinterventions might be the preferable option, also when considering Quality of Life (QoL). Currently information on QoL in elderly HD patients is still lacking. However, this information is crucial in the choice of therapy in these patients.

The present study compares the outcome of autologous RCAVFs and BCAVFs in our institutions in the HD population of 75 years and older and evaluates the QoL of the elderly HD patients.

METHODS

We consulted the institutional review board (AMOA) of the Amphia hospital, and they confirmed that no formal written waiver for the need of ethics approval was required because of the retrospective design of the study. Also there was no written consent needed from the patients.

Trial design

The study was performed at the departments of surgery and dialysis of the Amphia hospital in Breda and St Elisabeth Hospital in Tilburg, the Netherlands. Dialysis and operating room records from 2001 through 2008 were reviewed to identify all patients of 75 years and older undergoing a vascular access procedure for HD. Autogenous RCAVFs and BCAVFs were included in this study. Information about patient demographics, comorbidities, and previous dialysis access procedures was collected. Follow-up data were obtained from the hospital records.

Work-up and surgical Procedure

Fistula placement was preferably performed in the most distal portion of the nondominant arm. Clinical judgment as well as preoperative duplex ultrasonography was used to assess vascular anatomy and to determine the diameters of the radial and brachial arteries and the cephalic vein with minimum acceptable threshold for internal diameters set at 2.0 mm.[6] The AVF procedures were autogenous RCAVFs and BCAVFs.

Definitions

The surgical procedure was considered successful if presence of a thrill on palpation and/or auscultation was determined the day after the operation. Primary patency or intervention-free access survival was defined as the interval between access placement until any intervention designed to maintain or reestablish patency, access thrombosis, or the time of measurement of patency.[7,8] Primary-assisted patency was defined as the interval between access placement until any preemptive surgical or endovascular repair without access to thrombosis. Secondary patency was defined as the interval between access placement until access abandonment or the time of patency measurement including intervening manipulations (surgical or endovascular interventions) designed to re-establish functionality in thrombosed access.[7,8] Primary failure or inadequate maturation was defined as an AVF that did not develop to maintain dialysis or thrombosed before the first successful cannulation for HD treatment, at 6 weeks after surgery.[6,7] The AVFs that never matured were included in the patency rates.

QoL assessment

Patients were asked to fill out the World Health Organization Quality of Life assessment instrument (WHOQOL-BREF), which is an abbreviated version of the original WHOQOL-100.[9,10] This questionnaire was sent to the patients in January 2010. The questionnaire consists of 26 questions, and 24 questions assess the domains physical health (7 questions), psychological health (6 questions), social relationships (3 questions) and environment (8 questions). Each question has a 5-point Likert scale. The other 2 questions assess Global QoL and general health. Instructions of the World Health Organization (WHO) scoring were used to calculate the various QoL domains.[11] Likert scale data were converted into raw domain scores of the 4 distinct domains and transformed on a range from 0 to 100 , with higher scores corresponding with a better QoL. Raw QoL domain scores of our population were compared with raw QoL domain scores of patients 3 months after peripheral bypass surgery in our institution as studied by Öztürk et al.[12]

Statistical analysis

The SPSS 18.0 for Windows package (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Frequencies and descriptive statistics were used for reporting the baseline characteristics of the patient group.

Patency rates were transformed into a dichotomous outcome for specific time periods (1 year and 2 years). Data of access sites were assessed to be either patent or thrombosed at the end of each time period. The number of outcome events is represented by the number of thrombosed fistulae. Primary failures were included in the patency rates.

Patency rates were calculated with the Kaplan-Meier curves and the log-rank test was used to determine statistical significance. A *P*-value below 0.05 was considered to denote statistical significance. Dates of death were recorded. Patients who died or lost for follow up were censored for analysis. Descriptive analyses were used to calculate means and medians on each part of the QoL.

RESULTS

Baseline characteristics

From 2001 to 2008, a total of 107 permanent vascular accesses in 90 patients were recorded in the database. Mean age was 78 years (range 75-88) and 59 were males (66%). A total of 17 (19%) patients received more than 1 AVF during this observation period. A total of 65 (61%) AVFs were created at the wrist and 42 (39%) AVFs at the elbow. A total of 58 (54%) fistulae were actually used for dialysis, 41 (38%) fistulae were never cannulated and 8 (8%) fistulae dialysis records provided insufficient information about its cannulation. Of the 41 fistulae that were never used, in 9 cases the patient died, in 27 fistulae there was primary failure, and in 5 cases HD never started. In the primary failure group, 4 fistulae could not be cannulated because of inadequate maturation, 14 fistulae were occluded before first cannulation, 2 fistulae were abandoned because of steal; in 2 cases, cannulation was not successful and in 5 cases, dialysis records only reported primary failure. Baseline characteristics of the 90 HD

Table 1. Baseline characteristics

Characteristic	*RCAVF (N=65)*	*BCAVF (N=42)*	*P value**
Age, years (range)	78 (75-88)	77 (75-84)	
Male sex (%)	44 (68%)	26 (62%)	0,54
Coronary artery disease (%)	50 (77%)	31 (74%)	0,71
Peripheral vascular disease (%)	22 (34%)	16 (38%)	0,74
COPD (%)	19 (29%)	8 (19%)	0,22
Smoking (%)	17 (26%)	15 (36%)	0,35
Diabetes Mellitus (%)	22 (34%)	16 (38%)	0,74
BMI (range)	25 (16-41)	26 (19-34)	

Values are depicted as percentages or as median with range.
BMI = body mass index.
*Calculated by chi-square test

patients are shown in Table 1. There were no significant differences in gender and comorbidities between the RCAVF group and the BCAVF group.

Patency

Patency rates at 6 months, 1 year, and 2 years were determined. The results are shown in Table 2 and Figure 2-4. The primary patency rate (p=0,026) and the primary-assisted patency rate (p=0,016) of BCAVFs were significantly higher in comparison to RCAVFs. Also the secondary patency rates at 1 year (p=0,01) and 2 years (p=0,035) were significantly higher in BCAVFs, however secondary patency (p=0,14) rate was not significantly different between the groups. At the end of the study, 51 (57%) of 90 patients had died.

Table 2. Primary (PP), assisted (AP) and secondary (SP) patency rates at 6 months, 1 and 2 year according to type of fistula

Patency	*RCAVF (N=65)*	*BCAVF (N=42)*	*P-value*[*]
Primary patency rate (%)			**0,026**
At 6 months	39	58	0,14
At 1 year	31	52	0,01
At 2 year	22	41	0,009
Assisted patency rate (%)			**0,016**
At 6 months	50	68	0,21
At 1 year	34	54	0,034
At 2 year	25	49	0,011
Secondary patency rate (%)			**0,14**
At 6 months	69	84	0,056
At 1 year	58	70	0,010
At 2 year	50	57	0.035

[*]Calculated by log rank test

QoL analysis

Of the 90 patients included in this retrospective analysis, only 39 (43%) patients were alive in January 2010 and could be invited to participate in the QoL study, and 9 (23%) patients did not respond or failed to complete the questionnaire. Finally, data were available for 30 patients; 8 in the BCAVF group and 22 in the RCAVF group. Summary statistics of the raw domain scores for all 30 patients are listed in Table 3. On the domain of Global QoL a score of 71 (median 71,5) was found on a scale of 0-100. Raw domain scores in these patients were relatively high compared to raw domain scores of patients after peripheral bypass surgery.[12]

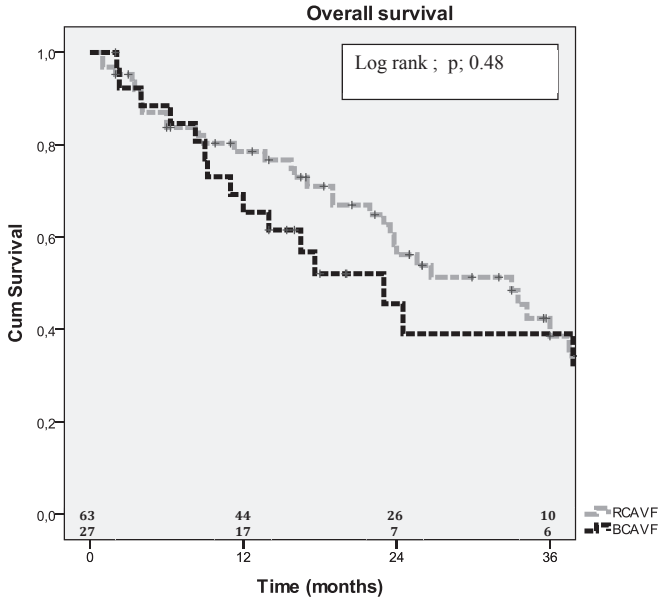

Figure 1. Overall 3-years survival in total study population.

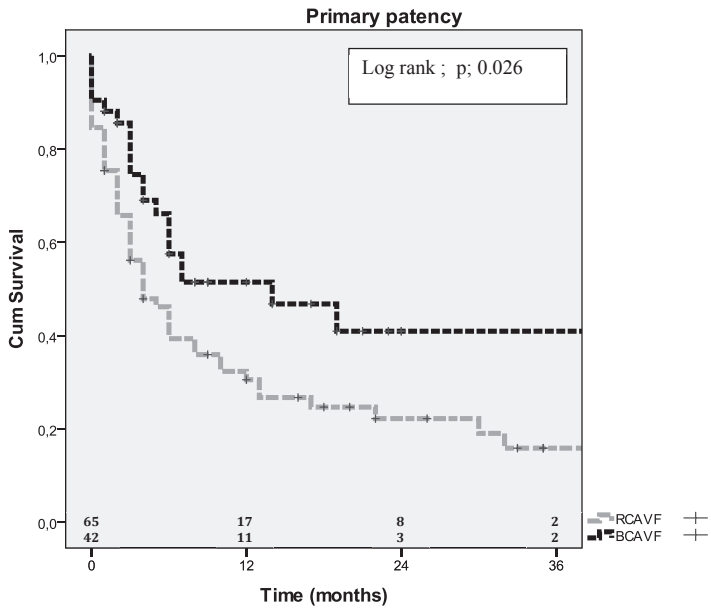

Figure 2. Kaplan-Meier curve of primary patency rates of RCAVF and BCAVF.

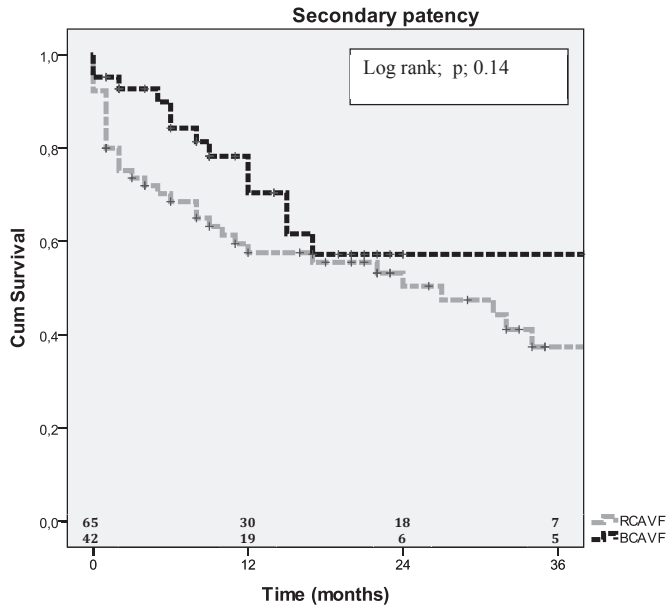

Figure 3. Kaplan-Meier curve of secondary patency rates of RCAVF and BCAVF.

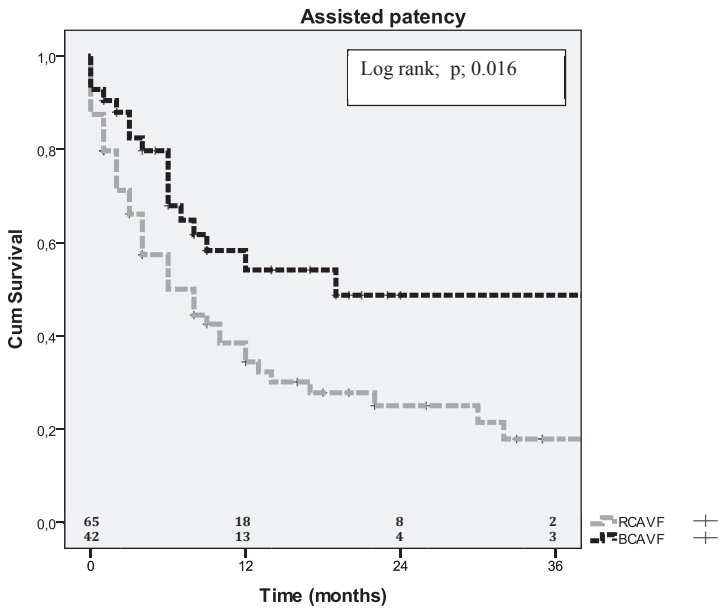

Figure 4. Kaplan-Meier curve of primary-assisted patency rates of RCAVF and BCAVF.

Table 3. Quality of life (QoL) analyses after fistula placement compared to QoL after autologous bypass surgery[26]

Domain	*Fistula (N=30)*	*Autologous bypass (N=33)*
Physical health	59	60.7
Psychological health	70	67.3
Social relationships	79	63.1
Environmental	75.5	68.9

DISCUSSION

According to demographic trends in the Netherlands, in the next 30 years the age category of 75 years and older is expected to double in size.[13] Also, a rapid increase of Dutch patients older than 75 years requiring dialysis is foreseen.[14] Next to a higher prevalence of end-stage renal disease (ESRD), these elderly people have important comorbidities, such as diabetes mellitus, cardiomyopathy, and peripheral vascular diseases.[15] The presence of these comorbidities and therefore an expected poor vessel quality challenge the creation of a reliable vascular access, which is a critical requirement for providing adequate HD.

Guidelines for vascular access do not include special recommendations for the elderly patients. Randomized controlled trials comparing dialysis access outcome in the elderly patient are lacking. The rationale for the DOQI to recommend RCAVFs before BCAVFs are lower morbidity rates associated with their creation, greater durability compared with other access types, and conservation of proximal access sites for future use.[4] An increased risk of RCAVF failure in the elderly patient and benefit of BCAVFs was reported in a meta-analysis.[4] However, studies reporting on outcome of RCAVFs and BCAVFs in the elderly patients are difficult to interpret due to different patient populations, different cutoff points for age groups, and different outcome measures regarding patency. However, our study in elderly patients shows significant higher primary, primary-assisted and secondary patency (at 1 and 2 years) rates in elderly patients with BCAVFs compared to patients with RCAVFs. This means that patients who received BCAVFs had a larger intervention-free and thrombosis-free access survival and time to access abandonment was longer. This lower reintervention rate is essential for this specific population of elderly HD patients in which, according to other studies, poor survival was measured.[3,16] We believe that in a group of patients with a short life expectancy, preservation of future access sites is less important. Because of this, we propose BCAVFs to be first choice fistula in the elderly patient.

Next to patency rates, another key outcome measure in the elderly is the QoL, which is increasingly being evaluated for other vascular interventions.[17] The QoL is defined by the WHO as

an individual's assessment of physical, psychological and social well-being that incorporates a patient's individual perception of its disease and functioning.[10] Psychometric properties of the WHOQOL-BREF are good with studies that have shown good internal consistency, validity, and good sensitivity to change.[18,19] In our study, a relative high overall global QoL score was measured. Due to the poor survival in the studied population, the QoL analysis could only be performed in a relative small amount of the patents that made it impossible to compare QoL between the BCAVF group and RCAVF group. Despite these small numbers, we think it is important to describe the QoL in this population. The fact is that most patients in which QoL was measured belonged to the RCAVF group. The RCAVF group had the worst patency and most re-interventions, so QoL was measured in the group of patients with the worst outcome. Our high QoL scores are consistent with the literature on this subject. Elderly dialysis patients have been found to be more accommodating to their disease and dialysis.[20,21] Besides this, QoL of the elderly dialysis patient did not differ greatly when compared to the QoL of an elderly person from the general population and patients after peripheral bypass surgery, as we also demonstrated.[12,22] So these elderly dialysis patients, in which survival was poor, seems to maintain a relative high QoL despite the discomforts of dialysis. It remains important to incorporate QoL in dialysis care, since perceived mental health seems to be a predictor of morbidity and mortality in patients with ESRD and therefore a measure of the quality of dialysis care.[23] This could be done by incorporating QoL questionnaires in the admission protocol for access surgery.

CONCLUSION

The BCAVFs should be considered before RCAVFs in HD access in elderly patients because of a longer intervention-free and thrombosis-free interval time. The QoL was surprisingly high in this population despite a high mortality rate.

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Chapter 3

Treatment for critical lower limb ischemia in elderly patients

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ABSTRACT

Background: Critical limb ischemia (CLI) has a poor outcome when left untreated. The benefits of revascularization in the very elderly might be limited because of co-morbidities and short life expectancy. Therefore, optimal management of CLI in the elderly is not straightforward. We analysed treatment results for elderly patients with CLI (Rutherford 4 or 5/6) in our clinic.

Methods: Hospital charts of all patients >70 years of age diagnosed with Rutherford stage 4-6 peripheral arterial disease between January 2006 and December 2009 were reviewed. We divided patients into two age groups (70-79 and ≥80 years) to compare treatment results. Primary interventions were defined as conservative, endovascular, reconstructive surgery, and amputation. Outcome measures were mortality, reintervention, and major amputation rates.

Results: There were 191 patients (99 (52%) were women), median age was 78,4 years, range 70-98 years. Altogether, 119 (62%) patients were aged 70-79 years, and 72 (38%) were ≥80 years. The primary intervention was equally divided over the two age groups (p=0,21). Trans-Atlantic Inter-Society Consensus on Management of Peripheral Arterial Disease (TASC II) classifications of aortoiliac lesions were not significantly different regarding intervention (p=0,62) or age (p=0,39). TASC II classification of femoropopliteal lesions was significantly different relative to intervention (p<0,01) but not different between age groups (p=0,68). Mortality rate after reconstructive surgery was significantly higher in the oldest age group (p<0,01). After conservative treatment, endovascular treatment or amputation, the mortality rates were not significantly different between the two age groups (respectively p=0,06; p=0.33 and p=0,76). Reintervention rate was 51 % in the 70- to 79-year group compared to 32% in the ≥80 year group. After initial treatment, major amputations were performed in 10% in the 70- to 79-year group compared to 13% in the ≥80 year group.

Conclusion: In patients aged ≥80 years, surgical revascularization resulted in a significant higher mortality rate in our clinic, whereas primary conservative, endovascular treatment and amputation resulted in similar mortality in both age groups. When considering surgical revascularization in the very elderly, surgeons should focus on careful patient selection.

INTRODUCTION

Critical limb ischemia (CLI) is the most advanced form of peripheral artery disease (PAD), presenting as ischemic rest pain, ulcers, or gangrene. It results from chronic, progressive, multilevel atherosclerotic lesions. [1] This severe type of vascular disease is associated with high morbidity and mortality rates and with diminished quality of life. [2,3] As the general population is growing older, an increasing number of very elderly patients suffer from CLI [2] The high prevalence of serious medical co-morbidities in this population affects outcome of treatment. Consequently, management of these patients can be difficult. [2] When left untreated, CLI is associated with a poor outcome. [4] Treatment options are bypass surgery and endovascular revascularization, such as balloon angioplasty with or without stent placement. In the absence of an outflow vessel or in the presence of severe co-morbidities that prohibit major surgery, amputation is a treatment option. Finally, some patients in the former category with limited tissue loss and good response to painkillers can be managed conservatively without amputation.

It is known that CLI patients who undergo successful revascularization survive longer and have an increased quality of life compared to patients who are treated conservatively or by primary amputation. [2] Not all revascularizations are successful however, and in elderly patients its benefits are curtailed by an increased (cardiovascular) morbidity and mortality. Furthermore, the very elderly have a shorter life expectancy. Therefore, the advantage of revascularization in elderly patients with CLI may be limited. There is conflicting evidence on the success of lower extremity bypass surgery and angioplasty in the elderly. [1-3] The BASIL trial is the only randomized trial on bypass versus angioplasty in critical limb ischemia. [5] The investigators concluded that patients with a life expectancy of more than 2 years perform better with surgical revascularization in terms of amputation free survival (AFS).

However, none of these papers described the outcome of all four management strategies, including amputation and conservative management. This study compared all four treatment options in elderly patients with CLI. Outcome was reported as 30-day, and 1- and 2-year mortality rates , reinterventions, and major amputations. The aim of our study was to evaluate treatment in our population of elderly patients suffering from CLI and analyse the rates of mortality and reinterventions after the initial treatment.

MATERIALS AND METHODS

Trial design

We performed a search of all patients with CLI treated in our hospital between January 2006 and December 2009. CLI was defined as stage 4-6 according the Rutherford classification. Data from patient records were collected in a database that contained the following items:

age, sex, date of first visit, level of PAD, TASC II classification [6], primary intervention, number and type of reinterventions, death, complications, co-morbidities (diabetes, smoking, hypertension, impaired renal function, heart failure). Primary interventions were classified as conservative, endovascular revascularization, surgical revascularization and major amputation. Reinterventions were endovascular revascularization, surgical revascularization, and minor and major amputation. The TASC II classification was determined based on angiography and/or Magnetic Resonance Angiography (MRA). We created two age groups: 70-79 years and ≥80 years. Outcome was measured in terms of mortality, major amputations and all reinterventions after four possible initial treatments. We calculated mortality at 30 days, and 1 and 2 years after the first intervention. All reinterventions and major amputations as a second intervention were specified per age group and first treatment group. Amputations were classified as minor (toe or forefoot) or major (above the ankle). If patients underwent only a minor amputation without revascularization, not followed by a major amputation within 1 week, we considered the treatment conservative. If a minor amputation was followed by a major amputation within 1 week, we considered the first intervention to be major amputation. Follow-up data were obtained from hospital records by K.L. and M.Z. If the date of death was not reported, one of the authors (K.L.) contacted the general practitioner to confirm the date.

Vascular workup and and treatment strategy

A vascular surgeon initially evaluated the patients, and an ankle-brachial index was determined. In addition, duplex scanning and/or MRA were used to evaluate treatment options. All patients received statins. Patients who were treated with an autologous peripheral bypass received oral anticoagulant (acenocoumarol), the other patients were given acetylsalicylic acid. A dedicated multidisciplinary vascular board comprising vascular surgeons and radiologists conducted a weekly review of the patiens. Before surgical revascularization, a cardiologist evaluated the patients to estimate the operative risk and optimize cardiac status if possible. Treatment policy was decided at the weekly board meeting based on technical possibilities and the patient's general health and severity of ischemia according the Rutherford index. In general the following strategies were initiated. Conservative management was started in patients with poor general health who had acceptable benefit from pain reduction therapy on rest pain or minor tissue loss (Rutherford 4-5). Endovascular treatment was the first choice whenever technically possible, depending on the morphology of arterial stenoses or occlusions in the affected limb. Surgical revascularization was planned for lesions not suitable for endovascular approach in patients with acceptable perioperative risk as estimated by a cardiologist, anaesthetist, and vascular surgeon. Three patients in the population 70-79 years of age underwent a suprainguinal bypass, as did two patients in ≥80 years group. All the other bypasses were infrainguinal. Primary amputation was performed in patients with severe ischemia (Rutherford 6) and general health deemed unfit for vascular reconstruction surgery or in the absence of a target outflow vessel.

Statistical analysis

SPSS 19.0 for Windows package (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Frequencies and descriptive statistics were used for reporting the baseline characteristics of the patient group. The chi-square test was used to determine statistical significance.

Survival interval rates were calculated with Kaplan-Meijer curves and the log-rank test was used to determine statistical significance. A value of $p < 0.05$ was considered to denote statistical significance.

RESULTS

This study included 191 patients, 99 (52%) of whom were women. The median age was 78,4 years (range 70-98 years). Risk factors for developing PAD and co-morbidity in this population were distributed as follows: smoking (34%), hypertension (62%), diabetes (50%), haemodialysis (9%), heart failure (57%). We divided the population in two age groups. There were 119 (62%) patients aged 70-79 years and 72 (38%) patients aged ≥80 years. The ≥80 years group contained significantly more women (p<0,01). Disease severity was classified as Rutherford 4 in 100 (52%) patients and as Rutherford 5/6 in 91 (48%) patients. We noted a trend towards Rutherford 5/6 in patients aged ≥80 years (p=0,09). The younger group contained more smokers (p<0,05), other risk factors and co-morbidities were not significantly different (Table 1).

Table 1. Demographic characteristics in different age groups with chronic critical limb ischemia

Characteristic	*70-79 (N=119)*	*80+ (N=72)*	*P value*[*]
Age, y, mean ± SD	74,5 ± 2.8	85,0 ± 4,2	
Gender (%)			<0.01
males	71 (60%)	21 (29%)	
females	48 (40%)	51 (71%)	
Risk factors and comorbidity (%)			
Smoking	48 (40%)	17 (24%)	<0.05
Diabetes	64 (54%)	32 (44%)	0.21
Hypertension	78 (66%)	40 (56%)	0.17
Hemodialysis	10 (8%)	8 (11%)	0.35
Heart failure	67 (56%)	42 (58%)	0.78
Rutherford classification			0.09
Class 4	68 (57%)	32 (44%)	
Class 5/6	51 (43%)	40 (56%)	

[*]Calculated by chi-square test

Patients were stratified according to the primary treatment strategy: conservative treatment in 20 (10%) patients; endovascular procedure in 89 (47%); surgical revascularization in 61 (32%); major amputation in 21 (11%). Types of primary intervention were equally divided in the two age groups (p=0,21) (Table 2).

Table 2. Types of first intervention according to different age groups

Intervention	*70-79 (N=119)*	*80+ (N=72)*
Conservative	9 (8%)	11 (15%)
Endovascular	55 (46%)	34 (47%)
Reconstructive Surgery	43 (36%)	18 (25%)
Major Amputation	12 (10%)	9 (13%)

*Calculated by chi-square test 'chi-square = 4.593[a] df (3); p = 0.21'

We found data to determine severity of PAD according the TASC II classification in 173 patients, but no data were found for the other 19 patients. The TASC II classification of aortoiliac lesions showed no significant difference in relation to intervention (p=0,62) or age (p=0,39). TASC II classification of femoropopliteal lesions showed a significant difference in relation to intervention (p<0,01) Patients initially treated with reconstructive surgery and amputation had more severe lesions than patients treated conservatively and with an endovascular procedure. No significant difference was seen in relation to age (p=0,68). With regard to the number of outflow arteries, there was no significant difference in relation to intervention or age (p=0,06 and p=0,09, respectively) (Table 3).

Survival was measured at 30 days and 1 and 2 years after the first intervention. Among the patients treated conservatively, endovascularly, or with major amputation, there were no significant differences in survival between the two age groups. However, in the group treated conservatively there is a trend toward higher mortality rates in the oldest population. Among the patients who underwent reconstructive surgery as the primary treatment, patients aged ≥80 years had a significantly higher mortality rate than the younger patients (p<0,01) (Table 4).

Reintervention and major amputation following the initial treatment strategy were distributed as follows. After conservative treatment, two patients underwent a second intervention (each had a minor amputation but no major amputation). After initial endovascular treatment, 52% of patients underwent reintervention, with 10% having a major amputation. In the surgically treated group, 51% needed a second intervention and 11% a major amputation. After a major amputation five patients (24%) were amputated at a higher level (Figure 1 and Table 5).

Table 3. TASC-classification of aortic-iliacal lesions and femoral popliteal lesions and number of outflow arteries according type of intervention

	Intervention							
	Conservative		*Endovascular*		*Reconstructive Surgery*		*Amputation*	
	70-79 (N=7)	*80+ (N=8)*	*70-79 (N=55)*	*80+ (N=33)*	*70-79 (N=43)*	*80+ (N=15)*	*70-79 (N=6)*	*80+ (N=6)*
TASC aorto-iliac								
TASC*Intervention: p=0.62#								
TASC*Age groups: p=0.39#								
none	7 (100%)	8 (100%)	36 (65%)	27 (82%)	31 (72%)	11 (73%)	5 (83%)	6 (100%)
Type A	-	-	9 (16%)	4 (12%)	5 (12%)	2 (13%)	1 (17%)	-
Type B	-	-	6 (11%)	2 (6%)	4 (9%)	-	-	-
Type C	-	-	3 (5%)	-	2 (5%)	1 (7%)	-	-
Type D	-	-	1 (2%)	-	1 (2%)	1 (7%)	-	-
TASC femero-popliteal								
TASC*Intervention: p<0.01#								
TASC*Age groups: p=0.68#								
none	-	1 (13%)	3 (5%)	-	-	-	-	-
Type A	2 (29%)	1 (13%)	9 (16%)	8 (24%)	5 (12%)	2 (13%)	-	-
Type B	4 (57%)	2 (25%)	36 (65%)	19 (58%)	24 (56%)	7 (47%)	2 (33%)	3 (50%)
Type C	-	3 (37%)	4 (7%)	4 (12%)	13 (30%)	6 (40%)	1 (17%)	2 (33%)
Type D	1 (14%)	1 (13%)	3 (5%)	2 (6%)	1 (2%)	-	3 (50%)	1 (17%)
Outflow arteries								
Outflow*Intervention:p=0.06#								
Outflow*Age groups: p=0.09#								
none	1 (14%)	2 (25%)	2 (4%)	3 (9%)	1 (2%)	1 (7%)	2 (33%)	1 (17%)
1-vessel	3 (43%)	3 (37%)	16 (29%)	15 (45%)	18 (42%)	8 (53%)	4 (67%)	2 (33%)
2-vessel	1 (14%)	3 (37%)	16 (29%)	10 (30%)	16 (37%)	3 (20%)	-	3 (50%)
3-vessel	2 (29%)	-	21 (38%)	5 (15%)	8 (19%)	3 (20%)	-	-

#Calculated by chi-square test

DISCUSSION

Our most important finding was the fact that surgical revascularization is a very high risk procedure in patients aged ≥80 years with CLI in our clinic. In our population, the 22% 30-day mortality was high compared to no mortality after endovascular treatment and primary amputation. In the longer term, these differences in mortality between the different management strategies were even more pronounced in the group ≥80 years. Arvela et al. described high operative risk of patients aged ≥80 years with CLI and a short life expectancy in a earlier study. [7] Currently, there are no specific guidelines for the treatment of elderly patients with chronic CLI, and decision-making is a challenge for the vascular surgeon. Untreated chronic

Table 4. Mortality rates at 30-days, 1-year and 2-years after first intervention according to different age groups

Intervention groups	*70-79 (N=119)*	*80+ (N=72)*	*P-value**
Total			
30-day mortality rate	8/119 (7%)	5/72 (7%)	
1-year mortality rate	20/119 (17%)	24/72 (33%)	
2-year mortality rate	29/119 (24%)	32/72 (44%)	
Conservative			0.06
30-day mortality rate	0/9 (0%)	1/11 (9%)	
1-year mortality rate	0/9 (0%)	6/11 (55%)	
2-year mortality rate	2/9 (22%)	7/11 (64%)	
Endovascular			0.33
30-day mortality rate	4/55 (7%)	0/34 (0%)	
1-year mortality rate	8/55 (15%)	8/34 (24%)	
2-year mortality rate	12/55 (22%)	9/34 (26%)	
Reconstructive			<0.01
30-day mortality rate	3/43 (7%)	4/18 (22%)	
1-year mortality rate	8/43 (19%)	9/18 (50%)	
2-year mortality rate	10/43 (23%)	12/18 (67%)	
Amputation			0.76
30-day mortality rate	1/12 (8%)	0/9 (0%)	
1-year mortality rate	4/12 (33%)	1/9 (11%)	
2-year mortality rate	5/12 (42%)	4/9 (44%)	

*Calculated by log rank test

Table 5. Re-intervention and major amputation rates after first intervention according to different age groups

Patient outcome (N=191)	*70-79 (N=119)*	*80+ (N=72)*	*Total (N=191)*
All re-interventions (%)	**61 (51%)**	**23 (32%)**	**84 (44%)**
Conservative	2/9 (22%)	0/11 (0%)	2/20 (10%)
Endovascular	30/55 (55%)	16/34 (47%)	46/89 (52%)
Reconstructive Surgery	25/43 (58%)	6/18 (33%)	31/61 (51%)
Amputation	4/12 (33%)	1/9 (11%)	5/21 (24%)
Major amputations (%)	**12 (10%)**	**9 (13%)**	**21 (11%)**
Conservative	0/9 (0%)	0/11 (0%)	0/20 (0%)
Endovascular	4/55 (7%)	5/34 (15%)	9/89 (10%)
Reconstructive Surgery	4/43 (9%)	3/18 (17%)	7/61 (11%)
Major amputation	4/12 (33%)	1/9 (11%)	5/21 (24%)

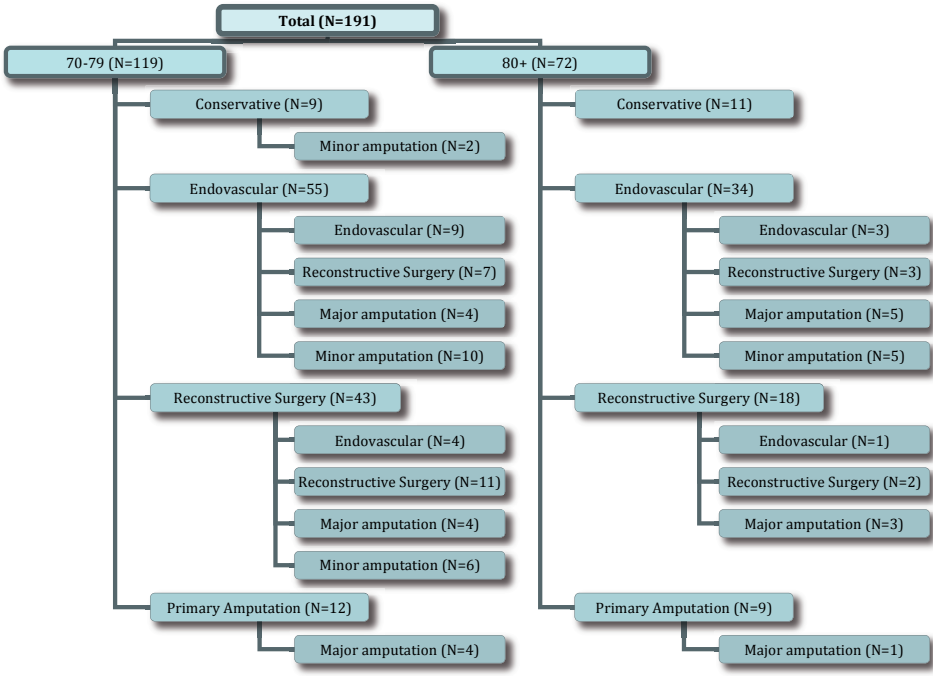

Figure 1. Flowchart of first intervention and re-interventions according to age groups.

CLI is associated with a dismal prognosis. [8] Multiple studies have shown that successful surgical revascularization in CLI patients has a positive effect on survival and quality of life when compared to conservative treatment or primary amputation. [8-10] Our results showed a similar trend in the younger age group. The surgical and endovascular groups had a better survival. Advanced age is considered a relative contraindication for surgical revascularization in patients with PAD. [1] In contrast, some institutions have described excellent results of CLI treatment in the elderly. In a retrospective study, Pomposelli reported good short- and long-term outcomes after 292 bypass operations as limb salvage for patients ≥80 years. [2] The 5-year survival rate was 44% with a limb salvage rate of 92%. Brosi et al reported a 30-day mortality of 6% after endovascular treatment, 20% after surgical revascularization, and 17,9% after conservative treatment in octogenarians in a prospective cohort study. [1] They concluded that revascularization in octogenarians is worthwhile but comes at a cost of a higher periprocedural mortality. However, the did not report the follow-up of patients treated with primary amputation. The result of our study in the ≥80 years group are comparable to those of Brosi et al. with a 30-day mortality of zero after endovascular treatment, 22% after surgical revascularization, and 9% after conservative management. In our population primary amputation did not lead to any deaths in nine patients after 30 days. This was probably due to the small numbers.

In the literature, reconstructive vascular surgery of the lower limb is associated with high perioperative cardiovascular risk, with mortality rates range from 2% to 6%. [2-4] We found similar 30-day mortality rate of 7% in patients aged 70 to 79 years, but in the ≥80 years group we found a 30-day mortality rate of 22%. Also, the overall mortality rate after reconstructive surgery was significant higher in patients aged ≥80 years. This raises the question at what cost limb salvage should be attempted in this high risk group. Alternative treatments, such as amputation or conservative treatment, could at least be considered with these mortality figures. However, we should bear in mind that a major amputation has a significant impact on the quality of life (QoL) and on survival. [11-13] On the other hand, revascularization does not prevent amputation in all cases. In our study, 51% of patients treated with surgical revascularization required reintervention, and this reintervention was a major amputation in 24%. Whether this influences the quality of life in these patients was not measured in this study, but it can be assumed that this has a negative effect.

Other studies have also shown that in very elderly patients the benefit of surgical revascularization is limited because of an increased risk of cardiovascular events. [14-16]

Two large clinical trials described long-term survival of patients with CLI after revascularization: 85 % 1-year survival in the PREVENT III trial and 70% 2-year survival in the BASIL trial. [5,17] We showed a 1-year survival of 82% after endovascular treatment and 70% after surgical revascularization, which is comparable to the results of the BASIL trial. [5] In the ≥80 years group, however, vascular surgery was associated with 50% mortality at 1 year, again raising the question whether surgery is feasible in this group. Lepäntalo and Matzke described a cohort of patients with CLI where no reconstruction was performed. [4] At 1 year, 54% of the legs were saved, and survival was 46%. This is considered a poor outcome, but it might be the best option in very high risk patients with controllable pain and limited tissue loss.

We are aware that the definition of CLI is important in this matter. CLI with limited tissue loss or pain can be managed conservatively in the non-ambulant elderly, whereas severe tissue loss in patients with a vascular lesion unsuitable for endovascular treatment represents the other end of the spectrum. In all age categories, the patient groups treated with endovascular intervention had lower mortality compared to the other treatment groups. These differences can of course be partly explained by the selection of patients by the vascular surgeon. This selection is illustrated by the significantly less extensive disease according to the TASC II classification in patients treated by endovascular means. The surgical revascularization and primary amputation groups represent a category with severe CLI unsuitable for conservative or endovascular treatment, because we use the 'endovascular first' strategy, especially in the very old. Therefore, we believe that it is possible to compare the amputation and surgical groups in terms of mortality.

We believe that patient selection could be the key to improving results of CLI treatment in the elderly population. Even though cardiovascular assessment by a cardiologist before surgical reconstruction is standard procedure in our clinic, it could not prevent a high mortality among very old patients. For the benefit of the patient and in light of the curtailment of healthcare costs, it would be worthwhile to prevent futile efforts in limb salvage. Risk prediction has been described by Schanzer et al. [18] Their group was able to identify patients with a more than 50% risk of death or amputation at 1 year. In future efforts for limb salvage in the very elderly, risk prediction could improve results. A risk score was not used in our clinic during the study period but will be calculated in a recently started prospective study in our department.

Although TASC II classifications were similar in the two age groups, the number of outflow vessels was significantly less in the group ≥80 years. This was not reflected in a different primary treatment strategy (Table 5) but could account for worse outcome in the elderly group. On the other hand, we found no significant differences in co-morbidity or disease severity according to the Rutherford classification in the two age groups. As mentioned above, the four types of primary intervention were similarly distributed in both age groups, suggesting that patient's age did not affect the treatment choice of the surgeon. In our opinion, the study design gives a realistic view of everyday vascular surgical practice and evaluates the performance of our clinic regarding the treatment of CLI. [19] This has encouraged us to start a prospective observational study for treatment of CLI in the elderly.

We are aware that treatment decisions in CLI should be individualized and based on life expectancy, functional status, anatomy of the arterial occlusive disease and surgical risk. [13,20] A better estimation of the surgical risk would be helpful. However, determining what surgical risk is acceptable when facing a major amputation is even more difficult. This is an important issue on an individual level and on socioeconomic level. Future studies should measure QoL and attempt better risk prediction to improve outcomes of treatment of CLI.

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Chapter 4

Outcome of elective treatment of abdominal aortic aneurysm in elderly patients

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ABSTRACT

Introduction: Optimal management of an abdominal aortic aneurysm (AAA) in the elderly is not straightforward. We evaluated treatment results of elderly patients with asymptomatic abdominal aortic aneurysm that met the treatment criteria in our clinic.

Methods: Hospital charts between January 2005 - December 2012 were reviewed of all patients 70 years and older diagnosed with AAA with a diameter that met the treatment criteria. Patients were stratified by age (group I: 70-79 years, group II: 80 years or older) and treatment. Outcome was measured in terms of survival and complications.

Results: In total 283 patients (240 (85%) men, median age 77,4 years) were included, 211 (75%) in group I and 72 (25%) in group II. There was an overall significantly higher mortality rate in the octogenarians ($p<0.01$). This difference was not seen in the groups treated conservatively and with OPEN repair. However, in the EVAR group there was a significantly higher mortality rate in octogenarians ($p<0.01$).

Conclusion: Long-term outcome after EVAR procedures results in higher mortality rates for the population older than 80 years as compared to the group aged 70-79 years.

INTRODUCTION

Abdominal aortic aneurysm (AAA) is a common vascular disease and can lead to serious life-threatening complications if left untreated in patients with a diameter over 55 mm. AAA is diagnosed in 5-10 % of men aged 65 years or older. [1] Approximately 75% of AAAs are asymptomatic and are found coincidentally during physical examination or by ultrasonography or CT scanning. [2]

Optimal management of an AAA is not straightforward. Treatment of AAA should be based on patient's comorbidity and aorta morphology. An important issue in decision-making is the size-related risk of aneurysm rupture in relation to the mortality risk of a surgical intervention. [2]

Open abdominal repair (OPEN) was for many years the gold standard for treatment of AAA. [3] However, endovascular aortic repair (EVAR) is a safe and effective alternative treatment option, which made it possible to treat a larger proportion of the population suffering from AAA. [4] The EVAR-1 trial revealed similar overall mortality rates in patients after undergoing EVAR and/or OPEN repair of an AAA. However, the long-term complications and reinterventions after EVAR were more common among older patients. [5] In case of significant comorbidity can be chosen for a conservative treatment. Given the increased risk of rupture this should be done in good consultation with the patient.

Despite the Society of Vascular Surgery / North American Chapter of the International Society for Cardiovascular surgery (SVS/ISCVS) [6] - and the European Society for Vascular Surgery (**ESVS)** [7] reporting standards, treatment of AAA should be based on the individual patient. Especially in elderly patients with considerable comorbidity it remains difficult and challenging to choose the best option of treatment. For this reason we evaluated treatment results of elderly patients with abdominal aortic aneurysm that met the treatment criteria in our clinic. The aim of this study was to determine the optimal treatment of asymptomatic AAA in elderly patients. In addition, we conducted a systematic review of the literature concerning treatment of AAA in elderly patients.

PATIENTS AND METHODS

I. Analysis of registered data

Patients' characteristics

A retrospective observational clinical review was conducted from data of 283 consecutive AAA patients treated between January 2005 and December 2012 at the vascular surgery department of the Amphia Hospital. Patients were stratified by age: patients between 70 - and 79 years (group I) and patients 80 years or older (group II). Data of the patient characteristics are listed in Table 1. The study conforms the STROBE guidelines

Table 1. Patient and AAA-characteristics of all patients aged 70 years or older treated for AAA during the study period

Characteristics	**Group I** *(n=211)*	**Group II** *(n=72)*	*P*-value*
GENDER			0,46
Male	177 (84)	63 (88)	
Female	34 (16)	9 (12)	
AGE (years, mean±SD)	75,3±3,0	83,5±2,7	
RISK FACTORS			
Smoking	71 (34)	5 (7)	<0,01
Diabetes	27 (13)	7 (10)	0,49
Hypertension	94 (45)	22 (31)	<0,05
COPD	40 (19)	21 (29)	0,30
Heart failure	84 (40)	42 (58)	<0,01
MEDICATIONS			
Statins	143 (68)	41 (57)	0,10
Acetylsalicylic acid	154 (73)	49 (68)	0,42
Acenocoumarol	23 (11)	10 (14)	0,50
ASA-CLASSIFICATION			0.26
Classification 2	80 (38)	19 (26)	
Classification 3	122 (58)	49 (68)	
Classification 4	9 (4)	4 (6)	
DIAMETER AAA			
Aneurysm (mean;min;max) mm	62;40;110	64;50;95	0,16

Data are presented as n and (%), unless otherwise specified.
AAA=Abdominal aorta aneurysm; *ASA*=American Society of Anesthesiologists; *Group I*= patients between 70-79 years; *Group II*=patients 80 years or older.
*Calculated by Chi-square test

Risk factors and comorbidity

Risk factors and comorbidity were registered prospectively of all patients during their visit to the outpatient clinic. The risk factor and comorbidity management, according to the Trans-Atlantic Inter-Society Consensus Document on Management of Peripheral Arterial Disease (TASC) [8] and the American Heart Association/American College of Cardiology (AHA/ACC) [9] were either conducted by a vascular specialist or cardiologist preoperatively in the outpatient clinic or during admission before operation. The American Society of Anesthesiologists (ASA) classification [10] of patients was determined according to their general preoperative condition prospectively. Data of the risk factors and comorbidity are listed in Table 1.

AAA characteristics

Indications for aneurysm repair were an aneurysm diameter ≥ 5.0 (female) or ≥ 5.5 (male) or growth of the aneurysm >0.5 cm within 6 months. Exclusion criteria comprised patients who needed branched or fenestrated stent grafts, patients with juxtarenal, - suprarenal, - or thoraco - abdominal aneurysms or patients presenting with a symptomatic - or ruptured AAA. The surveillance (with a Siemens Definition CT-scan) protocol was CTA at 1 - and 12 months after EVAR, and if no complications were detected, a CT (without contrast) in association with plain abdominal X-ray annually thereafter. Data of the AAA characteristics are listed in Table 1.

Treatment

Figure 1. is a flow chart of the different treatment options and their general criteria. In this study patients with symptomatic and ruptured AAA were excluded.

Conservative. Conservative management was started in patients where the operation risk was estimated greater than the mortality risk due to rupture of the aneurysm. This group contains mostly patients with advanced age, poor general health and an aneurysm that was not suitable for endovascular treatment.

OPEN. For all OPEN procedures the Dacron aorta graft was used.

EVAR. Three different stent graft systems were used for endovascular treatment of the AAA during the study period: Cook® Zenith Flex® AAA Endovascular Graft [11], Gore® Excluder® AAA Endoprosthesis [12] and the Medtronic® Endurant® AAA Stent Graft System [13].

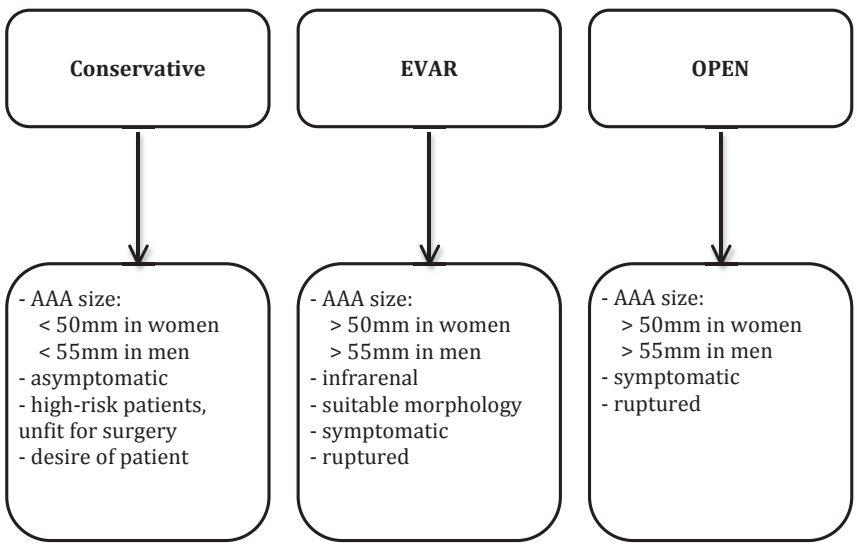

Figure 1. flow chart of treatment options.

The EVAR - and OPEN procedure were performed according to standard vascular - and endovascular techniques. All EVAR - and OPEN procedures were performed by a vascular surgeon. The requirements for these standard available stent grafts were driven by the Society of Vascular Surgery / North American Chapter of the International Society for Cardiovascular surgery (SVS/ISCVS) [6] - and the European Society for Vascular Surgery (**ESVS)** [7] reporting standards. Data of the EVAR procedures are listed in Table 2.

Table 2. Summary of EVAR procedures (*n*=120), endoleak (n=18) and reinterventions (*n*=8).

Revascularization	**Group I** (n=85)	**Group II** (n=35)	*P*-value*
EVAR			0,72
Medtronic® Endurant® AAA Stent Graft System	57 (67)	26 (74)	
Cook® Zenith Flex® AAA Endovascular Graft	24 (28)	8 (23)	
Gore® Excluder® AAA Endoprosthesis	4 (5)	1 (3)	
Endoleak †			0,65
Type 1	2 (2)	0 (0)	
Type 2	11 (13)	5 (14)	
REINTERVENTION	8	-	
Embolectomy	4	-	
Postoperative bleeding	2	-	
Stentgraft/extension	1	-	
Urokinase	1	-	

Data are presented as n and (%), unless otherwise specified.
AAA=Abdominal aorta aneurysm; *EVAR*=Endovascular aneurysm repair; *Group I*= patients between 70-79 years; *Group II*=patients 80 years or older.
†: defined according to the 2011 guidelines of the European Society for Vascular Surgery (ESVS)[15]
*Calculated by Chi-square test

Complications

In the Netherlands, the Association of Surgeons of the Netherlands (ASN) has agreed on one common definition of complications. [14-16] The definition of a complication is: "an unintended and unwanted event or state occurring during or following medical care, that is so harmful to a patient's health that (adjustment of) treatment is required or that permanent damage results. The complication may be noted during hospitalization, until 30 days after discharge or transfer to another department.

The definition of endoleaks, the decision to intervene and the type of reintervention, endovascular (stent graft, percutaneous embolization) - or surgical reintervention (ligation), were driven by the SVS/ISCVS - and ESVS reporting standards. [6,7] Endoleak type 1 was defined as a graft that does not seal completely at the extremities, endoleak type 2 as backfilling of the aneurysm from other smaal vessels in the aneurysm wall. Data of the endoleaks are listed in Table 2.

II. Review of the literature

A systematic search of literature was performed in the medical database PubMed. In addition, we manually searched the reference lists of relevant articles to identify articles missed by electronic searches. Language was restricted to English, German and Dutch. We did not systematically search abstract books of conference proceedings, did not hand search-leading journals, and did not contact leading authors in the field to retrieve potential extra papers.

Types of studies

Any prospective or retrospective study evaluating the treatment of AAA in elderly patients was considered. The studies had to be published from January 2003 till December 2012. They had to describe an original patient series of elderly AAA patients. Studies had to describe a consecutive patient series to be eligible for inclusion.

Study selection

Titles and/or abstracts of all selected manuscripts in the initial search were screened by two reviewers (KL and HF) independently to identify potentially relevant articles, using the inclusion criteria. Discrepancies in judgment were resolved after discussion and, when necessary, after mediation of a third reviewer (LL). Full text of these articles was retrieved for further analysis.

Study quality and data extraction

Studies fulfilling all inclusion criteria were checked on study quality characteristics by two reviewers (KL and HF) independently. Assessment of study quality was done using a form based on a checklist of the Cochrane Library. [17]

Registration and statistical analysis

SPSS 20.0 for Mac (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Frequencies and descriptive statistics were used for reporting the baseline characteristics of the patient group. The chi-square test was used to determine statistical significance. Survival interval rates were calculated with Kaplan Meijer curves and the log-rank test was used to determine statistical significance. A *p*-value below 0.05 was considered to denote statistical significance.

RESULTS

I. Analysis of registered data

Patients' characteristics, comorbidity and AAA characteristics

There were 283 AAA patients (group I: *n*=211, 75% vs. group II: *n*=72, 25%) included. This population consisted of 240 men (85%) and 43 women (15%). Median age was 77,4 years (range 70-91). The 30-day postoperative mortality rate was 1,4%. Risk factors and comorbidities were distributed as follows: hypertension (41%), diabetes (12%), heart failure (45%), COPD (22%), smoking (27%) and 14% had already stopped smoking. Group I contained significantly more smokers ($p<0.01$) and more patients with hypertension ($p<0.05$) or heart failure ($p<0.01$), while other risk factors and comorbidities were not significantly different. No significant differences were found in use of statins and anticoagulation medication. ASA classification was not significantly different between age groups ($p=0.26$; Table 1). However, ASA classification was significantly higher in the conservative treated total ($p<0.01$) and youngest ($p<0.01$) group and a similar trend was seen in the oldest group ($p=0.06$; Table 3). The mean diameter of the aneurysms was: mean 62 mm (range 50-110) in group I and 64 mm (range 50-95) in group II (Table 1).

Table 3. ASA classification according to intervention.

groups	**ASA 2**	**ASA 3**	**ASA 4**	*P*-value*
Group aged 70-79				**P<0,01**
Conservative	5	17	7	
EVAR	36	47	2	
Open repair	39	58	0	
Group aged 80+				**P=0,06**
Conservative	4	21	4	
EVAR	12	23	0	
Open repair	3	5	0	
Total				**P<0,01**
Conservative	9	38	11	
EVAR	48	70	2	
Open repair	42	63	0	

Data are presented as n, unless otherwise specified.
ASA=American Society of Anesthesiologists; *EVAR*=Endovascular aneurysm repair
*Calculated by Chi-square test

Treatment

Patients were stratified according to their treatment strategy: conservative *n*=58 (21%); EVAR *n*=120 (42%) and OPEN *n*=105 (37%). In both age groups an equal percentage of patients were treated with EVAR. However, in group II significantly more patients were treated conservatively compared to the patients in group I ($p<0.01$; Table 4).

Table 4. Type of interventions according age group

Intervention	**Group I** *(n=211)*	**Group II** *(n=72)*
Conservative	29 (14)	29 (40)
EVAR	85 (40)	35 (49)
Open repair	97 (46)	8 (11)

Data are presented as n and (%), unless otherwise specified.
EVAR=Endovascular aneurysm repair; *Group I*= patients between 70-79 years; *Group II*=patients 80 years or older.
*Calculated by chi-square test 'chi-square = 36,547a df (2); p < 0,01'

The EVAR stent graft systems were divided as follows: in the period 2005-2008 we used the Cook® Zenith Flex® AAA Endovascular Graft (*n*=32, 27%) or Gore® Excluder® AAA Endoprosthesis (*n*=5, 4%) and since 2008 we used the Medtronic® Endurant® AAA Stent Graft System (*n*=83, 69%). The occurrence of reinterventions after EVAR (*n*=8, 7%) was: embolectomy (*n*=4, 50%), postoperative bleeding (*n*=2, 25%), stentgraft/extension (*n*=1, 13%) and urokinase (*n*=1, 13%) as listed in Table 2.

Indications for reinterventions (*n*=15, 14%) after OPEN procedure were: postoperative bleeding (*n*=5, 33%), embolectomy (*n*=3, 20%), abdominal wound dehiscence (*n*=2, 13%), intestinal ischemia (*n*=2, 13%), suspicion of intestinal ischemia or postoperative bleeding, but not found during laparotomy (*n*=2, 13%) and lower limb amputation (*n*=1, 7%).

Complications

Endoleak. Endoleak type 1 or 2 were diagnosed in 18 patients: group I n=13 (15%) and group II *n*= 5 (14%). A reintervention for an endoleak was indicated in 2 patients from group I. There was no difference in occurrence and treatment of an endoleak after EVAR between both age groups ($p=0.65$; Table 2).

Systemic. Systemic complications occurred in 71 patients: OPEN n=48 (46%) and EVAR n=23 (19%) (Table 5).

Survival

As listed in Table 6, Figure 2-4 there was an overall significantly higher mortality rate in the group aged 80 years or older ($p<0.01$). In the conservative and OPEN group there was no difference between both age groups. However, in the EVAR group there was a significantly higher mortality rate in group II ($p<0.01$). In the conservatively managed group of patients

Table 5. Summary of complications after EVAR and OPEN repair and reinterventions.

Revascularization	**OPEN** (n=48)	**EVAR** (n=23)
SYSTEMIC COMPLICATIONS		
Pneumonia	9	1
Postoperative ileus	7	1
Delirium	5	1
Renal dysfunction	5	1
Heart failure	4	1
Myocardial infarction	4	2
Atrial fibrillation	3	4
Bladder retention	2	4
Respiratory insufficiency	2	1
Urinary tract infection	1	1
Seroma	-	2
Other	6	4

Data are presented as n, unless otherwise specified.
; *EVAR*=Endovascular aneurysm repair;

aged 70- to 79 years (*n*=29), 17 patients were deceased at the end of the follow-up, 1 patient (6%) died after a ruptured AAA, 6 (35%) due to recurrent disease and the cause of death of the other 10 patients (59%) could not be retrieved. In the conservatively managed group of patients aged 80 years and older (*n*=29), 22 patients were deceased at the end of follow-up, 6 patients (27%) died after a ruptured AAA, 2 (9%) due to recurrent disease and the cause of death of the other 14 patients (64%) could not be retrieved.

II. Systematic review of the literature

Study selection

The search identified 95 potentially eligible studies of which 83 were excluded based on title and abstract. From the remaining 12 studies full articles were collected and evaluated. Nine articles were according to our inclusion criteria and were included in the systematic review. Study flow and reasons for exclusion are presented in Figure 5.

Study descriptions

Characteristics and conclusions of the included and evaluated 9 articles [18-26] are outlined in Table 7 and 8. These articles represented 5110 elderly patients elective treated for AAA over a period of 10 years. Articles on surgery only for ruptured AAA were excluded. Only 3 studies (33%) were prospective and 6 studies (66%) were retrospective. These studies reported on

Table 6. Mortality rates at 30-days, 1-, 2-, 3- and 5-years after inclusion according to different age groups

Intervention groups	**Group I** (n=211)	**Group II** (n=72)	*P*-value*
TOTAL			**<0,01**
30-day mortality rate	2/211 (1)	2/72 (3)	
1-year mortality rate	27/211 (13)	20/72 (28)	
2-year mortality rate	38/211 (18)	26/72 (36)	
3-year mortality rate	48/211 (23)	30/72 (42)	
5-year mortality rate	58/211 (27)	36/72 (50)	
CONSERVATIVE			**0,68**
30-day mortality rate	1/29 (3)	2/29 (7)	
1-year mortality rate	12/29 (41)	13/29 (45)	
2-year mortality rate	15/29 (52)	16/29 (55)	
3-year mortality rate	16/29 (55)	18/29 (62)	
5-year mortality rate	17/29 (59)	21/29 (72)	
EVAR			**<0,01**
30-day mortality rate	0/85 (0)	0/35 (0)	
1-year mortality rate	6/85 (7)	6/35 (17)	
2-year mortality rate	10/85 (12)	9/35 (26)	
3-year mortality rate	13/85 (15)	11/35 (31)	
5-year mortality rate	15/85 (18)	14/35 (40)	
OPEN REPAIR			**0,46**
30-day mortality rate	1/97 (1)	0/8 (0)	
1-year mortality rate	9/97 (9)	1/8 (13)	
2-year mortality rate	13/97 (13)	1/8 (13)	
3-year mortality rate	19/97 (20)	1/8 (13)	
5-year mortality rate	26/97 (27)	1/8 (13)	

Data are presented as n and (%), unless otherwise specified.
EVAR=Endovascular aneurysm repair; *Group I*= patients between 70-79 years; *Group II*=patients 80 years or older.
*Calculated by Chi-square test

elderly patients undergoing EVAR (*n*=4), both OPEN and EVAR (*n*=4) and conservative (*n*=1) AAA treatment.

Patients characteristics

As listed in Table 8, a total of 4623 men (90%) and 487 women (10%) were evaluated, with a mean age of 75,7 years (range 68 - 85). The mean diameter of the aortic aneurysm was 60 mm.

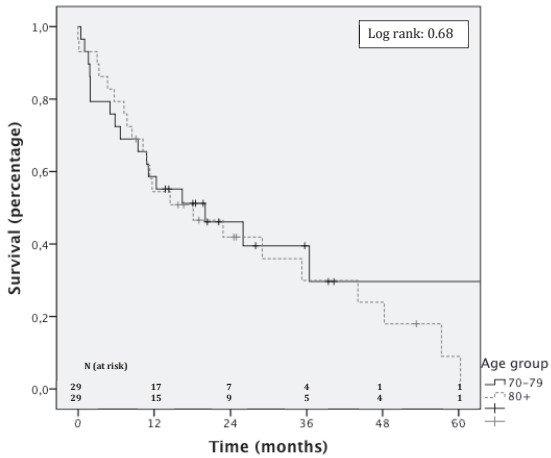

Figure 2. Kaplan Meier curve of survival after conservative treatment.

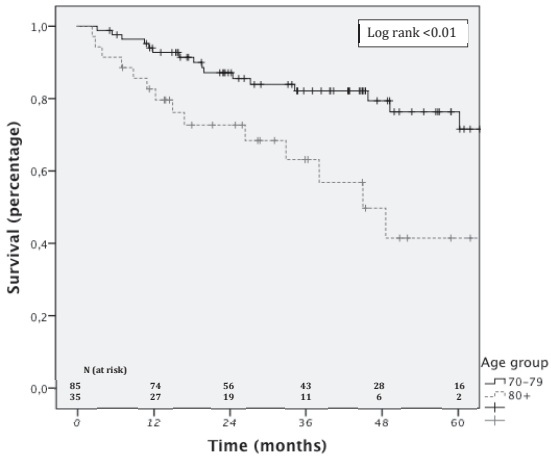

Figure 3. Kaplan Meier curve of survival after EVAR.

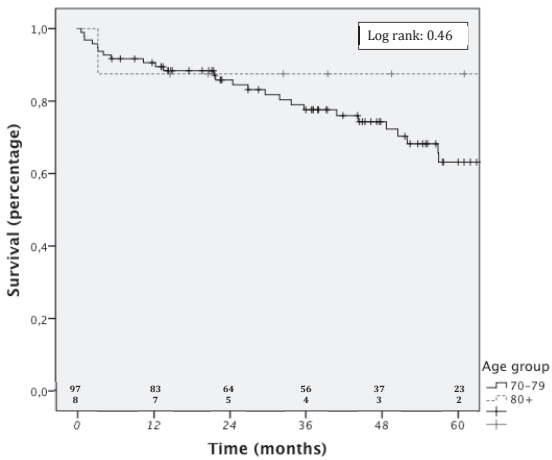

Figure 4. Kaplan Meier curve of survival after OPEN repair.

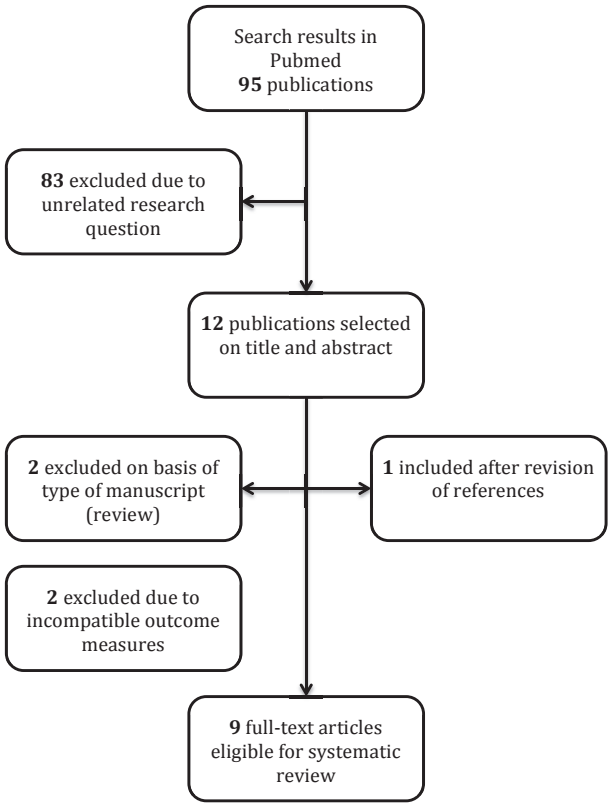

Figure 5. Study flow and exclusion criteria.

Treatment

EVAR

Four articles assessed mortality rates after EVAR. [18-21] These articles reported on patients aged 60 years and older undergoing EVAR as elective AAA treatment. Some articles (*n*=2) focussed specifically on "high risk" patients. High-risk criteria in these studies included age ≥ 60 years, ASA classification 3 or 4 and the comorbidity variables of history of cardiac, respiratory, or hepatic disease, cardiac revascularization, renal insufficiency, and low serum albumin level. [19,20]

The studies showed low perioperative mortality rates, ranging from 0,9% to 6%. [18, 20,21] However, this was higher compared to younger patients. [21] Two-year survival rates ranged from 68% to 84%.

EVAR in octogenarians resulted in acceptable midterm survival rates. [21] Age should therefore not be an exclusion criteria for EVAR and therefore EVAR can be an alternative for OPEN

Table 7. Study characteristics of the evaluated literature (concerning elective AAA treatment in elderly patients) [18-26] in this study.

No	Ref	Author	Study Design	Journal of Publication	Year of Publication	Patients (*n*)	Male (*n*,%)	Mean age (years)	AAA size, Mean mm	Peri-op mortality (%)	Technical succes (%)	2-year Survival rate (%)
EVAR												
1.	18	Brinkman et al.	Retrospective	AVS	2004	31	29 (94)	83	59	6	90	68
2.	19	Böckler et al.	Retrospective	Zentralbl Chir	2007	654	604 (92)	68,5	48	0,9	NR	NR
3.	20	Sobocinski et al.	Retrospective	AVS	2011	191	181 (95)	74,7	NR	1,6	99	84
4.	21	Geisbüsch et al.	Retrospective	JVS	2011	279	238 (85)	84,6	NR	2,8	95	79
EVAR vs OPEN												
5.	22	Sicard et al.	Prospective	JVS	2006	626	545 (87)	EVAR: 75,7	EVAR: 64	EVAR: 2,9	NR	EVAR: 74
								OPEN: 74,2	OPEN: 66	OPEN: 5,1		OPEN: 86
6.	23	Manis et al.	Prospective	VES	2006	107	90 (84)	EVAR: 78,6	EVAR: 56	EVAR: -	NR	NR
								OPEN: 73,0	OPEN: 62	OPEN: 1,3		
7.	24	Bush et al.	Retrospective	JVS	2006	2368	2351 (99)	EVAR: 71,8	NR	EVAR: 3,4	NR	EVAR: 90*
								OPEN: 72,9		OPEN: 5,2		OPEN: 88*
8.	25	Wahlgren et al.	Prospective	JVS	2008	700	585 (84)	EVAR: 75	NR	EVAR: 4,6	NR	EVAR: 84*
								OPEN: 73		OPEN: 3,3		OPEN: 92*
CONSERVATIVE												
9.	26	Noronen et al.	Retrospective	EJVS	2013	154		79,6	NR	-		50
					Total	**5110**	**4623 (90)**	**75,7**	**59,5**	**3,4**	**95**	**80**

AVS= Annals of Vascular Surgery; Zentralbl Chir= Zentrallblatt für Chirurgie; *JVS*= Journal of Vascular Surgery; *EJVS*= **European Journal** of Vascular & **Endovascular Surgery; VES= Vascular and Endovascular surgery; NR=not reported.**

***1-year survival rate (%)**

Table 8. Study conclusions of the evaluated literature (concerning elective AAA treatment in elderly patients) [18-26] in this study.

No	Ref	Author	Journal of Publication	Year of Publication	Conclusions of the study	Reason
EVAR						
1.	18	Brinkman et al.	AVS	2004	In Octogenarians with mild to moderate medical comorbidities, EVAR is an alternative for OPEN repair	- Low operative comorbidity scores, - Good clinical success rate.
2.	19	Böckler et al.	Zentralbl Chir	2007	Elective EVAR in patients aged 75 years and older does not demonstrate any benefit in midterm outcome	- Higher endoleackage-, conversion and renal infarction rates. - - Higher aneurysm related morbidity and mortality.
3.	20	Sobocinski et al.	AVS	2011	EVAR of AAA in high-risk patients is justified	- Perioperative mortality rate was low - 2-year survival rate was 84%
4.	21	Geisbüsch et al.	JVS	2011	Age of >80 years should not be an exclusion criteria for EVAR	- Higher but still low perioperative mortality compared to younger patients. - Acceptable midterm survival rates
EVAR vs OPEN						
5.	22	Sicard et al.	JVS	2006	EVAR in high-risk patents is safe and may be the best treatment option for this patients	- EVAR mortality remained comparable with OPEN up to 4 tears - EVAR provides protection from AAA-related death
6.	23	Manis et al.	VES	2006	OPEN repair in low-risk patients is associated with risk comparable to that of EVAR	- OPEN repair requires less frequent postoperative monitoring
7.	24	Bush et al.	JVS	2006	Elective EVAR should be considered in high-risk patients	- Outcomes after elective EVAR are excellent - Postoperative and 1-year mortality rate lower than OPEN repair
8.	25	Wahlgren et al.	JVS	2008	Elective OPEN repair in high-risk patients seems to have a better outcome compared with EVAR	- OPEN repair had lower 1-year mortality rate - More bleeding complications in EVAR group
CONSERVATIVE						
9.	26	Noronen et al.	EJVS	2013	Aneurysm rupture rate is relatively high among conservatively treated patients unfit for surgery. Operative management in these patients should be considered	- A ruptured aneurysm is the most common cause of death among patients unfit for surgery - 40% of patients survived the ruptured AAA operation

AVS= Annals of Vascular Surgery; Zentralbl Chir= Zentrallblatt für Chirurgie; *JVS*= Journal of Vascular Surgery; *EJVS*= ***European Journal*** of Vascular & ***Endovascular Surgery; VES= Vascular and Endovascular surgery;***

repair in elderly patients. [18,21] Also, in "high risk" patients EVAR for AAA was justified with a 2-year survival rate of 84%. [20] In contrast, one study demonstrated no benefit in midterm outcome in patients ≥ 75 years and treated with elective EVAR. [19]

OPEN vs. EVAR

Four articles compared mortality rates between EVAR and OPEN. [22-25] The best treatment option for elective AAA in high-risk patients remains unclear, as the different papers report in contrast to each other: comparable mortality rates after EVAR and OPEN repair up to 4 years [22] versus lower 1-year mortality rate after EVAR compared to OPEN repair [24] versus the opposite. [25]

Conservative

One article reported on conservative treatment of asymptomatic AAA that met the treatment criteria in "high risk" patients unfit for surgery. [26] They concluded that aneurysm rupture rate is relatively high among conservatively treated patients unfit for surgery. Given the fact that 5 out of 12 patients survived the ruptured AAA operation, they state that operative management in these patients should be considered.

DISCUSSION

This study demonstrates higher mortality after conservative treatment of an abdominal aortic aneurysm that meets the treatment criteria as compared to EVAR in the extreme fragile elderly patients. Despite this finding, the survival of these fragile patients is 45% after two years. So, there may be a place for conservative (no operation) treatment in fragile patients unfit for surgery with an AAA. Another important finding was the fact that mortality after endovascular treatment of AAA in patients aged 80 years and older was significantly higher compared to the younger group, while no differences between age groups were measured in the conservative and OPEN group.

Elective treatment of AAA in the elderly is more common as a result of an aging population and the increasing use of CT scans detecting incidental AAAs. [27] However, there is still little data available on outcomes of EVAR and open repair in elderly patients. EVAR has become the treatment of choice in patients not eligible for open repair. [1,4] Patients undergoing EVAR are supposed to have fewer complications, shorter hospital stay, and earlier return to their function compared to patients treated with open repair. [4] Earlier studies demonstrated EVAR as a safe procedure to manage AAA in the elderly with a 30-day mortality rate of less than 2%. [26-29] Our study shows similar results in short-term survival. However, long-term survival is not taken into account in these studies. EVAR has been demonstrated to reduce mortality and

complication rates in the first month after the procedure compared with open repair. [5,30,31] Although EVAR is less invasive than open repair, endoleaks and endograft failure leads to a greater number of re-interventions. [30] Especially in elderly patients, these re-interventions have more impact on their general health. Raval et al. concluded that EVAR is superior to open repair in octogenarians and must be the treatment of choice in these patients. [27] In contrast, our study shows that patients aged 80 years and older had poorer survival compared with younger patients after EVAR, but not after open repair. Furthermore, we found worse survival after EVAR in octogenarians as compared to open repair. To this last conclusion should be noted, however, that the group octogenarians who underwent an OPEN repair was very small.

The EVAR-1 trial showed similar overall mortality rates in patients after undergoing EVAR and/or open repair of an AAA. [5] EVAR was postulated as a minimally invasive approach of an AAA in patients unfit for major surgery. But the EVAR-2 trial showed no survival benefit for EVAR compared with conservative management and concluded EVAR was not a safe procedure in high-risk patients. [32] Additional to these results we found significantly worse survival in octogenarians undergoing EVAR compared to younger patients.

Particularly in a population of patients with shorter life expectancy it remains important to focus on quality of life as an important outcome measurement. This study does not report about the quality of life after operative or conservative treatment of an AAA. Earlier, the EVAR 1 and 2 and the DREAM trial reported conflicting results on outcome of quality of life after EVAR and open repair. [5,28,30,32] They all reported decrease in quality of life after EVAR and open repair of AAAs. These studies do not describe the feasibility of conservative management of certain patients sustaining an AAA.

Our systematic review showed acceptable midterm survival rates after EVAR in octogenarians. [21] Age should therefore not be an exclusion criteria for EVAR and therefore EVAR can be an alternative for OPEN repair in elderly and fragile patients. [18,20,21] However, The best treatment option for elective AAA in high-risk patients remains unclear, as the different papers report in contrast to each other. [20, 22-25]

Because of its retrospective nature, our study has limitations, which should be considered when interpreting the results. First, a limitation of this study may be the restriction of data collection from only one hospital, which might not be completely representative for all hospitals. Second, the number of patients in the present study does not permit further analyses in dept. Third, this is an observational study on the outcome of AAA management in the elderly patients, it does not give an answer on the question which patients should receive

treatment and what kind of treatment. However, this observational study describes some important outcomes that can help us in further studies on this topic.

CONCLUSION

There are specific guidelines for the treatment of AAAs. These guidelines are based on the degree of dilatation of the aorta. However, patient general health, age and comorbidity are not taken into account in these guidelines. On the basis of our study we can't make a clear statement about the best treatment of AAA in elderly patients. We are aware that the definition of AAA is important in this matter. Asymptomatic AAA with diameters equal to or slightly larger than the treatment criteria can more easily be managed conservatively. We believe that patient selection could be the key to improve results of aneurysm treatment in the elderly population. However, very elderly fragile patients with AAA remain a difficult group to treat. A good risk analysis based on comorbidity, risk of rupture and mortality due to surgery is of great importance in these patients, but the desire of the patient remains the guiding principle.

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PART II

Outcomes of various aspects of orthopaedic trauma surgery in elderly patients

Chapter 5

Increasing rates of pelvic fractures among older adults, The Netherlands, 1986-2011

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ABSTRACT

Background: Age-related issues are expected to rise in the coming decades. Osteoporosis, falls and fractures are major public health issues among elderly. Pelvic fractures are associated with a serious morbidity and hospitalization rate. We therefore performed a study to determine trends in incidence and age-specific rates of pelvic fracture related hospitalizations amongst elderly (≥65 years).

Methods: A secular trend analysis of all hospitalizations due to a pelvic fracture among older adults, using the National Medical Registration, 1986-2011, The Netherlands.

Results: The total number of hospitalizations due to a pelvic fracture increased from 887 in 1986 to 2,013 admissions in 2011 (127% increase). The overall age-adjusted incidence rate increased from 5.19 in 1986 to 7.14 per 10,000 population in 2011 (37.5% increase). The incidence rate increased with age and was higher for females. The Percentual Annual Change (PAC) was 1.2% (95%CI 0.9;1.5) for older males, and 1.0% (95%CI 0.9;1.2) for females, respectively. The mean length of hospital stay decreased between 1991 and 2011 to 12.0 days (53.4% decrease). The total number of hospital-bed-days decreased from 29,002 days in 1991 to 17,283 days in 2011 (40.4% decrease), despite an increase in absolute number of admissions.

Conclusion: Absolute numbers and incidence rates of pelvic fractures are increasing among the older Dutch population. Considering the fact the general population is growing older, an increasing number of elderly suffer from pelvic fractures. Attention on osteoporosis screening and prevention of falls in elderly remains important, in order to limit related healthcare costs in the future.

INTRODUCTION

The population of older adults, aged 65 years and over, is increasing rapidly worldwide.[1] The increase of the older population is partly caused by a rising number of older adults, but also due to an increasing life expectancy. Consequently, age-related problems are rising, including osteoporosis and falls.[2, 3] Falls are the main cause of injuries among older adults, and leading to a high healthcare demand. One-third of the persons aged 65 years and older fall on average once a year.[4, 5] The majority of fall-related injuries among older adults, presenting at an Emergency Department, are fractures (60%) and superficial injuries (21%).[6] It might be expected that rates of pelvic fractures will increase in the near future.[7, 8] Fractures of the pelvic bones are associated with high rates of hospitalization and mortality.[9]

Worldwide, osteoporosis is a growing public health issue in developed countries.[10] People with osteoporosis, characterized by low bone mass and micro-architectural deterioration of bone tissue, have an increased risk of fractures.[11] Over 60% of the pelvic fractures are associated with osteoporosis. For patients aged 60 years and older the percentage increases to 94%.[12]

Accurate numbers and trends over time are needed to assign the limited healthcare resources in ageing populations. The Netherlands is an ideal country for such trend analysis, because of the extensive and long-term registration of all hospitalizations. Therefore, the aim of the current study was to provide secular trend analysis of numbers, incidences and age-specific rates of pelvic fractures hospitalizations among the older Dutch population.

PATIENTS AND METHODS

For this study, all hospitalizations due to a pelvic fracture among older adults were obtained from 1986 throughout 2011. During the study period, a pelvic fracture has been defined using the International Classification for Diseases, 9th revision (ICD 9) of the World Health Organization, code 808.[13] Persons aged 65 years and older were defined as 'the older population'. The method used in this study, has been used previously.[14, 15]

Data were obtained from National Medical Registration (LMR, Dutch Hospital Database, Utrecht), which is operated by the Consumer and Safety Institute, Amsterdam, The Netherlands.[16] In the LMR database information is stored of nearly all hospital admissions in The Netherlands with a uniform classification system, and with a high national coverage (missing values <5%, except in 2007 when 12% was missing). Data were extrapolated to full national coverage by the Consumer and Safety Institute. The extrapolation factor was based on the adherence population of the registering hospitals and the national Dutch population in each year of the study.[16] Information regarding hospital admissions, admission diagnosis, age, gender and length of hospital stay (LOS) in days is stored in this database. For each individual

patient only one injury code, the primary diagnosis, was used. The primary diagnosis is based upon the medical record of the treating physician (in general the most severe injury). During the study period the uniform classification and coding system for all hospitals used by the LMR did not change.

Numbers of hospitalizations due to a pelvic fracture were specified for age and gender. Demographic numbers were obtained from the Statistics Netherlands using the mid-year population numbers. [17] Incidence (crude- and age-adjusted) rates were calculated in 5-year age groups, for both males and females and expressed per 10,000 persons in the specified age groups. Age-adjusted incidence rates enabled us to compare the incidence rate for a standardized population during the study period. Demographic changes throughout the study period were corrected by "Direct Standardization". Numbers of hospital admissions and LOS in the period 1986 throughout 2011 were expressed as percentages compared to the index year 1986.

The medical ethical review board of the Erasmus MC, University Medical Center, Rotterdam, approved the study method (MEC-2010-402) and provided a waiver for 'informed consent', because the data were retrieved from a large public accessible database, containing anonymous data on admissions, which cannot be traced to individuals.

A linear regression model with Poisson error and log link (log was mid year population size in each year of the study) as offset factor was used to model the trend in hospitalizations. The parameter for calendar year, corrected for gender and age group, was transformed into Percentual Annual Change (PAC). The Statistical Package for the Social Sciences (SPSS) software (version 16.1.1) was used to perform all statistical analyses. A P-value <0.05 was considered statistically significant.

RESULTS

During the study period from 1986 until 2011 a total number of 34,307 patients, aged 65 years and older, had a pelvic fracture requiring hospitalization in the Netherlands. The annual number hospitalizations due to a pelvic fracture increased with 127% (from 887 admissions in 1986 to 2,013 admissions in 2011), **Figure 1**. The male-female ratio remained stable throughout the study period to approximately 1:4 (**Table 1**). During that same period, the population aged 65 years and older, increased from 1.77 million in 1986 to 2.595 million in 2011 (46.7% increase).

Gender and age-specific incidence rates for pelvic fractures are shown in **Table 2**. The incidence rates for females are higher than those for males, and increased with age for both genders. The overall age-adjusted incidence rate of hospitalizations related to a pelvic fracture increased from 5.19 per 10,000 population in 1986 to 7.14 per 10,000 population in 2011 (37.5% increase). For males, the age-adjusted incidence rate increased from 2.83 per 10,000

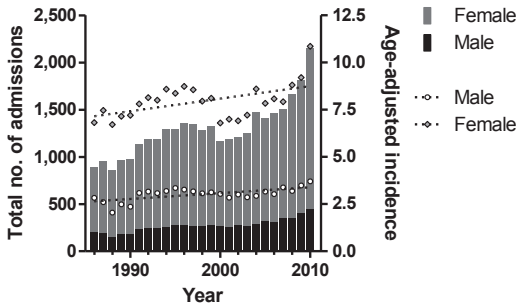

Figure 1. Total number of pelvic fracture related hospitalizations and age-adjusted incidence in persons aged 65 years and older, The Netherlands, 1986-2011.
Incidence rate is expressed per 10,000 older population. Dashed bars indicate a fitted regression line (P<0.001 for both males and females).

Table 1. The number of people aged 65 years and older, and pelvic fracture related hospitalizations in The Netherlands, 1986-2011

Charactaristic	1986	1991	1996	2001	2006	2011
Population (*1,000)	1,769	1,934	2,061	2,175	2,330	2,595
Female sex (%)	59.9%	60.2%	59.8%	58.9%	57.6%	56.0%
No. of admissions	887	1,125	1,357	1,184	1,464	2,013
Male, No. (%)	200 (23)	235 (21)	269 (20)	254 (21)	309 (21)	343 (17)
Incidence rate*	5.0	5.8	6.6	5.4	6.3	6.9
Admission duration, d	n.a.	25.8	19.5	18.1	13.1	12.0

*No.. Number; *Crude incidence rate per 10,000 population aged 65-years and older; d, days; n.a., not available*

Table 2. Age-specific incidence rates of pelvic fracture related hospitalizations in persons aged 65 years and older, The Netherlands, 1986-2011

	65-70 y		70-75 y		75-80 y		80-85 y		85-90 y		90-95 y	
Period	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
1986-1988	0.9	1.7	1.6	4.0	2.9	6.5	4.9	12.0	8.2	18.7	14.9	28.8
1991-1993	1.4	2.0	1.8	4.3	3.6	8.1	6.3	13.4	7.6	20.2	23.3	34.4
1996-1999	1.4	2.2	2.1	4.2	3.2	8.0	7.3	14.9	7.8	23.1	17.6	33.0
2001-2004	1.4	1.5	2.0	4.0	3.0	6.2	5.4	12.7	7.9	19.9	19.5	27.8
2006-2008	1.3	1.5	1.9	3.3	3.0	7.3	6.2	14.2	11.6	25.6	23.6	42.9
2009-2011	1.7	2.3	2.6	4.2	3.8	9.1	7.5	17.7	12.2	27.5	21.0	54.4
PAC (95%CI)	1.7% (0.9;2.5)	0.2% (-0.5;0.8)	1.4% (0.7;2.2)	-0.5% (-1.0;-0.1)	0.5% (-0.2;1.2)	0.6% (0.2;1.0)	1.0% (0.3;1.6)	1.1% (0.8;1.4)	2.0% (1.2;2.9)	1.5% (1.2;1.9)	1.5% (0.5;2.5)	2.3% (1.9;2.8)

Incidence rate is expressed per 10,000 older population. PAC, Percentual Annual Change; 95%CI, 95% Confidence Interval

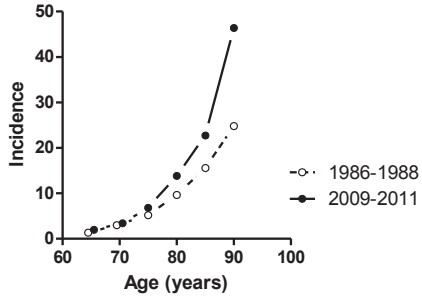

Figure 2. Age-specific incidence rate of pelvic fracture related hospitalizations in The Netherlands during the period 1986-1988 and 2009-2011.
Incidence rate is expressed per 10,000 population.

persons in 1986 to 3.68 per 10,000 persons in 2011 (30.0% increase). For females an increase was observed from 6.82 to 9.53 (39.7% increase) during the same period (**Figure 1**).

Age-specific hospitalization rates increased during the study period for both genders, in all age-categories (**Table 2**). The strongest rise in age-specific incidence was seen among persons aged ≥85 years (**Figure 2**). The Percentual Annual Change (PAC) was 1.2% (95%CI 0.9;1.5) for the older male population. For females the PAC was 1.0% (95%CI 0.9;1.2) during the study period. The PAC for the age-specific groups are shown in **Table 2**. There was a shift in the distribution of the different age-groups. The proportion of oldest old, persons aged 85 years and older, increased during the study period (**Figure 3).**

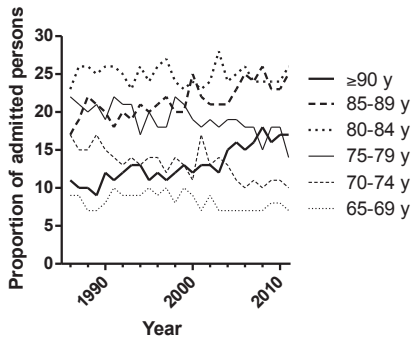

Figure 3. Proportion of different age group admitted with a pelvic fracture in The Netherlands, 1986-2011.

The mean admission duration among older adults admitted because of an pelvic fracture decreased over the last 20 years for all age-groups, from 25.8 days in 1991 to 12.0 days admission in 2011 (**Table 1**). Despite an increase in the total number of pelvic fracture related hospitalizations, the total number of hospital-bed-days decreased from 29,002 days in 1991 to 17,283 days in 2011 (40.4% decrease), due to the decrease in the mean admission duration.

In older males, it decreased from 7,857 days in 1991 to 4,745 in 2011 (decrease 39.6%). For females an decrease was seen from 21,145 days in 1991 to 12,537 hospital-bed-days in 2011 (decrease 40,7%), **Figure 4**.

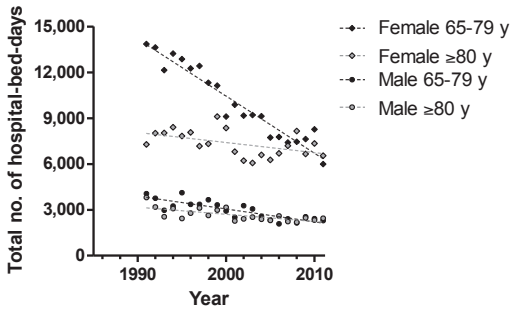

Figure 4. Total number of hospital-bed-days due to pelvic fracture related hospitalizations in The Netherlands, 1991-2011.
Dashed bars indicate a fitted regression line (P<0.05 for all groups).

DISCUSSION

In the current study secular trends of pelvic fracture related hospitalizations in the older Dutch population are shown. Both absolute numbers and incidence rates are increasing. However, the total number of required hospital-bed-days decreased during the study period due to a reduced length of hospital stay per admission.

Melton *et al.* reported an exponentially increase in the incidence of pelvic fractures in the USA in both elderly men and women.[18] Kannus *et al.* reported similar results in Finland over the period 1970-1997.[19] These findings are in concordance with our results. Pelvic fractures comprise less than 5% of all fractures in patients aged 80 years and older. However, these fractures constitute up to 23% of admissions to level 1 trauma centers in the USA. [20] Also, Matityahu *et al*. reported an increased rate of severe complications (e.g. renal failure, acute respiratory distress syndrome or pulmonary embolism) and mortality among the oldest old (80 years and older) with pelvic fractures.[21]

Because the population of older adults is increasing and the life expectancy is increasing, the proportion of older adults will increase in the next decades. The incidence of fragility fractures might be predicted to show a similar increase.[1] Related healthcare demands and healthcare costs are expected to show a comparable rise in the coming decades, on top of the rising incidence rates.

One of the most important factors of the related healthcare resources and costs, is the LOS per admission Over the last decades the admission duration has been reduced by over 50%. The reduction in LOS may, at least partly, be explained by better pain management and bet-

ter care during hospital stay with early mobilization under supervision of the physiotherapist. Also, early discharge to designated rehabilitation places and skilled nursing homes have contributed to this reduction in LOS.[22] The mean admission duration related to pelvic fractures was longer for patients who were not self-sufficient prior to the fracture. Furthermore, the high LOS can be attributed to complications associated with immobility. These complications are decreased muscle strength, deep venous thrombosis and pulmonary embolism, postural hypotension, decreased cardiac function, urinary retention and calculus formation, constipation, pressure ulcers, impaired pulmonary function resulting in pneumonia, and bone resorption with worsening osteoporosis.[12]

In The Netherlands all inhabitants enjoy a full health care insurance and full accessibility to the Dutch health care system. This system has been applicable during the whole study period. The study has been based on data retrieved from the electronic national population-based in-hospital data from 1986 until 2011. This highly accurate electronic database records with nearly complete national coverage all pelvic fractures related hospital admissions as well as hospital- bed- days in all hospitals in the Netherlands. It is important to mention that during the study period no changes in the coding system of the National Medical Registry occurred, nor were there major policy changes introduced affecting the increase in admission rates.

However, this study has a few notable limitations. First of all, linked administrative databases are prone to variation and coding errors. [23] A quality survey performed in 2002 by Paas *et al*, showed a high accuracy of coded injury data of the LMR database (correctly coded in 91% of cases and in 9% incomplete). [24] These data are comparable of a similar data registration from New Zealand (period 1996-1998). [25] The true number of pelvic fractures might be higher, because only the primary admission diagnosis was used. So in patients with multiple, more severe injuries were missed in this study. Furthermore, the database used does not contain clinical data regarding underlying diagnosis and co morbidities. Also no data were available as far as injury severity, lifestyle or medication of patients. Therefore the interpretation of causal mechanisms behind observed trends is limited. Possible explanations for the observed trends might be that the population is ageing, individuals are longer living independently, and with more comorbidities. Consequently, these people remain more mobile and the fall risk increases. Retrieved data only relates to patients in the Netherlands, the results may not be directly translated to other countries, as other healthcare system and different demographics may exist. Furthermore, readmissions were not excluded and some "double registration" could have occurred. However, it is unlikely that readmissions influenced our results, because readmissions constitute only 2.6% in the Netherlands, as was found in a study by Polinder *et al*.[26]

In conclusion, absolute numbers and incidence rates of pelvic fractures increased in the Netherlands. During the study period incidence rates increased with almost 50% in patients aged 65 years and older. However, the total number of hospital-bed-days was almost halved in the same period. As the general population is ageing, an increasing number of older

patients suffer from pelvic fractures. In order to limit related healthcare costs in the future, it remains important to keep attention on the prevention of falls and osteoporosis among older adults.

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Chapter 6

Proximal fractures of the humerus in patients older than 75 years of age: Should we consider operative treatment?

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ABSTRACT

Background: More than 75% of all patients presenting with a proximal humerus fracture are 70 years or older. Very little is known about the outcome after operative treatment of these fractures in very old patients. This study was performed to gain more insight in safety and functional outcome of surgical treatment of proximal humerus fractures in the elderly.

Materials and Methods: In this observational study, we analyzed all operatively treated patients, aged 75 years or older, with a proximal humerus fracture between January 2003 and December 2008 in our center. Patient selection was on clinical grounds, based on physical, mental and social criteria. Complications were evaluated. We used the DASH Questionnaire to investigate functional outcome, pain and ADL limitations.

Results: Sixty-four patients were treated surgically for a displaced proximal fracture of the humerus, 15 two-part, 32 three-part and 17 four-part fractures. Mean DASH scores in them were 37.5, 36.9, and 48.6, respectively. Regarding the operative methods, overall good results were obtained with the modern locked plate osteosynthesis (Mean DASH 34.4). Prosthetic treatment, mostly used in highly comminuted fractures, often resulted in poor function (Mean DASH 72,9). Persistent pain and ADL limitations were more present in more comminuted fractures (64 and 50% in patients with 4-part fractures vs 14% in patients with 2-part fractures). There were no postoperative deaths within three months of surgery, and fracture-related and non-fracture-related complication rates were low (non-union 3%; 1 myocardial infarction). *Conclusions*: This study shows that it is safe and justifiable to consider surgical treatment of a severely dislocated proximal humerus fracture in selected patients aged 75 and older.

INTRODUCTION

Up to 80% of fractures of the proximal humerus are suitable for conservative management, with the use of a sling and physical therapy. [1] However, if severe fracture dislocation is present, poor functional outcome of conservative treatment can be anticipated and surgical intervention must be considered. With the advent of more advanced implants and improved surgical techniques, surgical interventions for these fractures are gaining more acceptance. Possible advantages include faster mobilization, less pain, and better functional outcome. This is particularly true for younger patients. [2]

However, to our knowledge, there is no specific report about the outcome of surgically treated fractures of the proximal humerus in the very old patient.

In the older population, fractures of the proximal humerus are most common, after hip and wrist fractures. The incidence in patients over 70 years reaches up to 9 per 1000 population/year. This represents more than 75% of all proximal humerus fractures. [3,4]

Especially in view of the ever increasing elderly population, insight into functional outcome in this group is very important. Challenges in treating this population operatively are the presence of osteoporosis, higher risks for surgery and the difficulties in rehabilitation. Knowledge of the functional outcome in these patients may help in making the best choice of treatment in terms of quality of life and health care costs, giving them a chance to maintain an independent lifestyle.

This study was performed to gain more insight in the outcome, regarding postoperative mortality, pain, Activities of daily life (ADL) limitations, and functional outcome of surgically treated fractures of the proximal humerus in patients aged 75 years and older.

MATERIALS AND METHODS

This observational study was based on a single-centre retrospective research.

All patients operatively treated for fractures of the proximal humerus, from the age of 75 years and older between January 2003 and December 2008 were included in order to have at least 12 months of follow up. [5] The selection for operative treatment was first based on the configuration of the fracture, of which dislocation of fragments of the fracture is most important. Second, this selection was based on careful clinical judgment of the treating surgeon, considering the physical, mental and social condition of the patient. We excluded patients from the study who presented 14 days or more after injury, and patients with multiple fractures of the upper extremity. A total of 64 surgically treated patients were included, with an average age of 80.1 years (SD 3.8) at the time of injury. At the time of the research, 13 patients were lost to follow-up: 10 patients had died and 3 cases lacked contact information. Mean follow-up time was 3.7 years (SD 1.4).

Patient characteristics comprised age, gender, affected side, follow-up period, age at injury, risk of surgery as reflected by ASA-classification [6], and operative technique. Fracture classification was performed according to Neer. [7] This classification is primarily based on the number of main fracture fragments.

Various surgical techniques for reconstruction of the fracture were used. The most frequently applied techniques were open reduction and internal fixation (ORIF) using a locking compression plate (the Proximal Humeral Locking Plate (PHLP) or the Philos Plate, both Synthes, Switzerland), ORIF using K-wires and a tension band construction, or hemi-arthroplasty prosthetic repair (either the Global prosthesis, Johnson & Johnson, USA or the Articula prosthesis, Matthys, Switzerland). The choice for a specific operative technique was based on several factors: first, patient-related factors, such as frailty and more advanced age, were more often reason to use a less invasive operative technique such as ORIF using K-wires and a tension band construction; second, surgeon-related factors, such as more experience or education in one specific operative technique; and third, as the study progressed, the use of locking compression plates became more popular.

Postoperative rehabilitation protocol consisted of protected active and passive circumduction exercises during the first 4 weeks under supervision of a physiotherapist. Progressive active mobilization after 4 weeks was initiated when control X-rays were satisfactory and showed a stable and unchanged osteosynthesis.

Mortality and fracture-related complications such as nerve damage, wound infection and non-union were recorded. Also, relevant non-fracture-related complications, such as cerebrovascular accidents, sepsis or thromboembolic disease were researched from the patient files.

We used the DASH Questionnaire (Disability of Arm, Shoulder and Hand) to investigate functional outcome in 51 patients. The scores retrieved from the Questionnaires vary from 0 (a perfect function) to 100 (complete loss of function of the injured limb). Patients with severe psychiatric of physical impairment at follow up, could not be investigated by this questionnaire and were excluded from further analysis (n=8). A selection of the questions regarding pain and ADL limitations, were used to evaluate pain and ADL limitations as outcome measures.

RESULTS

In the 5-year period between January 2003 and December 2008, 64 patients aged 75 years or older, were treated surgically for a proximal fracture of the humerus. Patient characteristics are listed in Table 1. Ten patients were deceased by the time of this research, with a mean of 22 months after diagnosis (SD 18 months).

This population consisted of 15 patients with a two-part, 32 patients with a three-part, and 17 patients with a four-part displaced fracture of the proximal humerus.

Table 1: Patient characteristics

	All	% or (SD)	Functional Follow-up	% or (SD)
Patients	64	100	51	67
Age, mean	80.1	(3.8)	81.8	(4.3)
Gender: Female	58	91	48	94
Affected side: Right	26	41	15	38
Psychiatric/physical impairment	8	12	8	16
ASA Score, mean	2.4	(0.8)	2.3	(0.8)
Deceased	10	6.4	-	-
Days after surgery	670	(547)	-	-

ORIF using LCP osteosynthesis was used in 24 patients (7 two-part, 16 three-part, 1 four-part). ORIF with a tension band construction technique in 15 patients (2 two-part, 10 three-part, 4 four-part). In this group, 8 patients required re-operation due to secondary dislocation. A hemi-arthroplasty was performed in 16 patients (4 three-part, 12 four-part). Nine patients were treated with the use of other surgical techniques for internal fixation: intramedullary nail (n=4), single lag screws (n=3) or conventional (non-LCP) plate osteosynthesis (n=2). The exact distribution of the patients among the groups is set out in Table 3.

In this very old patient cohort, selected on clinical criteria of vitality, there were no postoperative deaths within three months of surgery. One patient developed a myocardial infarction postoperatively. Three patients were treated successfully for a urinary tract infection. Wound infection occurred in 1 patient and axillary nerve damage in 1 other patient. Osteonecrosis of the humeral head was not observed in this population. A non-union was observed in 2 patients treated with ORIF using LCP osteosynthesis (3%). Eight out of the 15 patients initially treated with ORIF using K-wire and a tension band wire required re-operation due to secondary dislocation. In these re-operated patients, neither mortality nor additional morbidity was observed.

In the evaluation of functional outcome in these patients, 43 patients were eligible for analysis. The mean DASH score in patients with a two-part fracture was 37.5 (n=7), in patients with a three-part fracture 36.9 (n=22). Patients having suffered a four-part fracture did significantly worse with a mean DASH score of 48.6 (n=14). Also the occurrence of moderate to severe pain and limitations in ADL increased significantly with increasing number of fracture parts. (table 2)

Analysis of the results according to the operative methods showed an interesting trend (Tables 2, 3). Mean DASH score in ORIF using either a LCP device (n=17), or a tension band wire technique (n=9), in spite of necessary re-operations was 34.4 and 33.9, respectively. Hemiarthroplasty patients fared less well, their mean DASH score was significantly higher with 53.9 (n=14). Moderate to severe pain and ADL-limitations were significantly less present (12 and 18%, respectively) in patients treated with LCP.

Table 2: DASH, pain and ADL-limitation by fracture classification and surgical technique

	Number of patients	DASH	Moderate/severe Pain (%)	Moderate/Severe ADL Limitations (%)
Fracture classification:				
2-part	7	37.5	1 (14)	1 (14)
3-part	22	36.9	7 (32)*	9 (41)*
4-part	14	48.6*	9 (64)**	7 (50)*
Surgical technique:				
LCP	17	34.4	2 (12)	3 (18)
K-wire/Tension band	9	33.9	5 (56)*	5 (56)*
Hemi-arthroplasty	14	53.9*	8 (57)*	7 (50)*

* P-value <0.05; ** P-value <0.001

Tabel 3. Detailed report of the study cohort

Neer	N included	N follow-up	repair	N included	N follow-up	Mean DASH	Moderate/ severe pain	ADL limitations
2part	15	7	LCP	7	3	31.4	0	0
			K-wire/ tension band	2 (1x reop)	1 (1x reop)	36.7	0	0
			Hemi-arthroplasty	0	-	-	-	-
			Nail	3	2	65.4	1	1
			Lag screws	2	1	13.3	0	0
			Non LCP	1	0	-	-	-
3part	32	22	LCP	16	13	36.4	2	3
			K-wire/ tension band	10 (7x reop)	6 (3x reop)	39.7	3	4
			Hemi-arthroplasty	4	2	22.9	1	1
			Nail	1	0	-	-	-
			Lag screws	1	0	-	-	-
			Non LCP	1	1	56.6	1	1
4part	17	14	LCP	1	1	0	0	0
			K-wire/ tension band	4 (0x reop)	3	20	2	1
			Hemi-arthroplasty	12	10	60.1	7	6
			Nail	0	-	-	-	-
			Lag screws	0	-	-	-	-
			Non LCP	0	-	-	-	-

DISCUSSION

Data in the current literature suggest that operative treatment of displaced proximal humerus fractures may have a better outcome compared to conservative treatment, but convincing evidence is not available. Especially in the older patients, considerable pain and functional limitations remain after both treatment modalities. [1, 2, 9-11]

The aim of this research was twofold. First, it was performed to study whether our policy of operative fracture management of the proximal humerus fracture in the very old, after deliberate and careful selection, was safe in terms of mortality and morbidity. Second, it was undertaken in order to study whether the functional results justified operative treatment of proximal humerus fractures in older patients. Of course, the first aim was of primordial importance; even if the results after surgery would be excellent and far better than conservative treatment, an elevated risk of mortality would raise considerable questions about a justified indication.

All patients in this study were operated only after careful selection on clinical grounds. All somatic risk factors were taken into account in our clinical judgment. Many patients included in this study, had cardiovascular or pulmonary comorbidities, as might be expected in this old population. However, patients considered not fit for surgery were treated conservatively with use of a sling. We would like to emphasize that mental vitality and social independency of the patients were also important factors in the decision making to perform surgery in case of a shoulder fracture. In this study, no patient died within 3 months of the operation or re-operation. This suggests that it is safe to perform this surgery in well-selected patients.

In a previous report by Owsley, locked plate fixation of humeral fractures in patients older than 60 years was associated with a high rate of screw cutout and revision surgery.[6] Surprisingly, the number of fracture- and non-fracture-related complications in our study was very low. Also in this regard, surgery of the shoulder in the selected very aged patients appeared to be safe.

Furthermore, the functional results of operative repair in general were satisfactory. As is known from the literature, the functional prognosis is worse as the number of fracture fragments increases: 4-fragment fractures generally fare much worse than 2- or 3-part fractures, whether treated conservatively or operatively.[7] This also appeared to be true in this cohort of elderly patients: The postoperative results of the 2- and 3-part fractures were satisfactory to good in most patients, with a mean DASH score in these groups of 37.5 and 36.9 respectively (Table 2). Four-part fractures, often treated with a hemi-arthroplasty, generally had a poor postoperative course with a mean DASH score of 53.9.

As to the type of osteosynthetic repair, some interesting findings were noted. Especially in the patients treated by ORIF with locked compression plates, adequate pain reduction and functional recovery was achieved. Although the tension band group seemed to do quite well, it should be kept in mind that these results were obtained after half of these patients

were re-operated. An extra operation in this group of patients is, of course, not desirable considering the perioperative risks. The tension band technique is often used for the treatment of unstable fractures by less experienced surgeons or in patients who were older or had more comorbidities, since it is less invasive, which resulted in re-dislocation of the fracture fragments in some cases. Often, the re-operations were performed by more experienced surgeons, resulting in an eventually good result. Fortunately, these re-operations did not cause further mortality or morbidity, and ended with good results.

In the studied population, pain experience, ADL limitations and the overall functional outcome as measured by the DASH score, is significantly worse after hemiarthroplasty compared to internal fixation. This finding is consistent with the results of prosthetic repair in younger groups [2] Hemi-arthroplasty was predominantly used in severely displaced and/or highly communitive fractures of the proximal humerus. Our rationale for operation was that highly communitive and dislocated fractures of the proximal humerus, especially in case of a luxated and avascular humeral head, warranted a prosthetic repair. The use of prosthetic repair was primarily intended for minimizing pain rather than regaining function. However, our study showed that severe pain often persists after hemiarthroplasty. It would be interesting to know how these patients would have fared with conservative treatment.

This study shows that it is safe and justifiable to perform osteosynthetic repair of a severely dislocated proximal humerus fracture in selected patients of 75 years and older. This might diminish pain and ADL limitations and potentially contribute to the preservation of an independent lifestyle.

Further research is needed to elucidate the true impact on quality of life of the very old patient, and to identify specific groups of patients or fracture types that are less suitable for surgical treatment.

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Chapter 7

Outcome after osteosynthesis of hip fractures in nonagenarians

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ABSTRACT

Background: Hip fractures in the elderly population are associated with high morbidity and mortality. However, there is still a lack of information on mortality and loss of independency in extremely elderly people with a hip fracture.

Objective: To study functional outcome and mortality after osteosynthesis of hip fractures in very old patients in our clinic.

Patients and Methods: Hospital charts of all patients over 90 years old operated for a hip fracture between January 2007 and December 2011 were reviewed. Outcome measures were mortality, preoperative and postoperative mobility, and loss of independency.

Results: A total of 149 patients were included, 132 (89%) women, median age 93,5±2,45 years. Thirty-six (24%) patients were classified as American Society of Anesthesiologists (ASA) grade 2, 104 (70%) as ASA 3 and nine (6%) as ASA grade 4. The Charlson comorbidity index (CCI) score was 2 or less in 115 (77%) patients and 34 (23%) patients scored 3 of more points. Short-term survival was 91% and 77% on 30-day and 3-months, respectively. Long-term survival was 64%, 42% and 18% at 1-, 3- and 5 years after surgery, respectively. Survival was significant better in patients with lower ASA score (P=0.005). No significant difference in survival was measured between patients according CCI score (P=0.13). Fifty-one percent of patients had to be accommodated in an institution with more care following treatment, and 57% was less mobile after osteosynthesis of a hip fracture.

Conclusion: Our study shows that short-term mortality rates in very elderly patients with a hip fracture are high and there is no clear predictive value for mortality. ASA classification is the best predictive value for overall mortality. A large proportion of these patients lost their independency after osteosynthesis of a hip fracture.

INTRODUCTION

Proximal femoral fractures are an important cause of hospitalization of elderly people, currently leading to nearly half of all injury-related health care costs of aged adults in The Netherlands.[1] Most hip fractures (80%) occur in persons aged 65 years and older.[2,3] This population is increasing rapidly worldwide.[4] The overall 1-year mortality rate associated with hip fracture is reported to be between 14% to 47%.[5,6] Still, there is missing data on functional outcome and mortality rates in extremely elderly patients.[7]

Demographic aging is caused by decreased fecundity along with the increasing life expectancy. Consequently, age-related problems are rising, including osteoporosis and falls.[1,8] Falls are the main cause of injury among elderly people, one-third of the persons over 65 years fall on average once a year, leading to a high health care demand.[9,10] The majority of fall-related injuries that required treatment in a hospital are fractures (60%) and superficial injuries (21%).[11] Older individuals in particular are at an increased risk of sustaining fractures due to underlying medical conditions, especially osteoporosis.[12,13] Typical osteoporotic fractures include those of the hip, wrist, vertebrae, and upper arm.[14]

Hip fractures, more than any other type of fracture, are associated with loss of independence, morbidity, and mortality, and have a major impact on the quality of life of the patients and their caregivers.[5,15,16,17] The care for these patients is complex and requires a multidisciplinary and multiagency input.[5]

Despite the increasing population of extremely old patients with hip fractures, data on mortality rates, predictive values of risk factors on mortality, and functional outcomes after osteosynthesis of hip fractures in these very old is still lacking. The aim of our study was to evaluate outcomes after osteosynthesis of hip fractures in a population of extremely old patients aged over 90 years.

PATIENTS AND METHODS

Study design

Patients aged 90 years and older presenting with a fracture of the hip were identified retrospectively from January 2007 until December 2011. All patients undergoing osteosynthesis of a hip fracture were included. Data from patient records were collected in a database containing the following parameters: type of hip fracture, comorbidity scores, type of intervention, time till intervention, age, clinical outcome and survival. The type of hip fracture was scored according the Müller AO classification of fractures. Comorbidity was assessed

by the Charlson Comorbidity index (CCI) score.[18] The CCI determines comorbidity level on the basis of the number and severity of 19 pre-defined conditions. It provides a weighted score of comorbidities, which can be used to predict short- and long-term outcomes such as function, length of hospital stay and mortality rates. The CCI is the most widely used scoring system for comorbidity used by researchers and clinicians.[18] The age-adjusted variant of the CCI was not used, because our study population contains only patients aged over 90 years. The preoperative conditions of patients was also scored according to the American Society of Anesthesiologists (ASA) grading scale.[19] The ASA physical status classification system is a system for assessing the fitness of cases before surgery. The American Society of Anesthesiologists (ASA) adopted the five-category physical status classification system; these are: 1. Healthy person; 2. Mild systemic disease; 3. Severe systemic disease; 4. Severe systemic disease that is a constant threat to life; 5. A moribund person who is not expected to survive without the operation. Interventions were osteosynthesis of a hip fracture with a Gamma nail (Stryker Corporation, Kalamazoo, MI, USA), Dynamic Hip Screw (DHS) or cannulated screws. Furthermore, the total preoperative delay (time between fracture and surgery), and preoperative hospitalization delay (time between admission and surgery) were calculated. Development of postoperative delirium was measured using hospital records. Delirium was diagnosed using the Delirium Observation Screening (DOS) scale. Outcome was measured in terms of mortality, morbidity and loss of independency. The consequence in terms of loss of independency was scored according change in place of residence and/or mobility. We contacted patients' general practitioner and/or place of residence to assess these variables. In the Netherlands, a nursing home is a place were elderly people who can't live independently anymore receive help with household tasks, personal care and meals. A care home is a place were people receive medical care after hospital stay or in case of prolonged illness. We also assessed predictive values of risk factors on mortality rates. We calculated mortality at 30 days, 3 months, 1 year, 3 year, and 5 years after intervention. Follow-up data were obtained from hospital records. If mortality was not reported, the general practitioner was contacted by the authors to determine survival.

Surgery

Patients were treated by a general or orthopedic surgeon. The type of hip fracture was evaluated by standard X-ray examination of the pelvis and broken hip. The type of osteosynthesis was determined at the discretion of the treating physician. Preoperatively, patients underwent cardiopulmonary and medical evaluation to estimate operative risk in order to optimize their general physical status if necessary. After surgery, mobilization and weight bearing bearing was allowed as soon as possible according to the surgeon's advice. Patients started to mobilize under the supervision of the physiotherapist.

Ethics approval

We consulted the institutional review board (Advisory commission involving Human Subjects Research Amphia Hosptital - AMOA) of the Amphia hospital and they confirmed that no formal written waiver for ethics approval was required, because of the retrospective design of the study. Also there was no written consent needed from the patients.

Statistical analysis

SPSS 19.0 for Windows package (IBM Corporation, Armonk, NY, USA) was used for the statistical analysis. Frequencies and descriptive statistics were used for reporting the baseline characteristics of the patient group. The chi-square test was used to determine statistical significance.

In univariate analysis survival probabilities were calculated with the Kaplan-Meier method. The log-rank test was used to determine statistical significance of the categorical variable at hand. Multivariate survival analyses were performed using the Cox proportional hazards model. A *P*-value below 0.05 was considered to denote statistical significance.

RESULTS

In total 149 patients were included, 132 (89%) were women and the median age was 93,5±2,45 years. Preoperatively, 36 (24%) patients were classified as ASA grade 2, 104 (70%) as ASA grade 3 and 9 (6%) as ASA grade 4 according to the ASA classification. The CCI score was 2 or less in 115 (77%) patients and 34 (23%) patients scored 3 of more points, which means a higher level of comorbidity preoperatively (Table 1). The type of hip fractures according different fracture classifications are listed in Table 2. Total follow-up ranged from less than 1 month to 70 months (mean 23 months), during which 99 deaths were observed.

After osteosynthesis the overall survival was 91% and 77% at 30 days and 3 months, respectively. Long-term survival was 64%, 42%, and 18% at 1, 3, and 5 years after surgery (Figure 1). When patients were divided according ASA classification, overall survival was significantly better in patients with an ASA score of 2 compared to patients with an ASA score of 3 or 4 (P=0.005, Figure 2). No significant difference in survival was measured between patients with a CCI score of 2 or less and patients with a CCI score of 3 or more (P=0.13, Figure 3). Mortality rates in relation to type of anesthesia (general or spinal) were not significantly different (P=0.82, Figure 4). There was no significant difference in mortality rates between patients operated in 24 hours after occurrence of hip fracture (N=96) and patients operated on after 24 hours (N=53) (P=0.62, Figure 5). Mortality rates were not significantly different between patients with and without post-operative delirium (P=0.37), nor between males and females (P=0.84). Fully independent patients had a significantly lower mortality rate

Table 1. baseline characteristics of 149 patients with hip fractures

Gender (%)	
men	17 (11,4)
women	132 (88,6)
Age (years) ± SD	93,5 ± 2,45
Charlson index score (%)	
0	35 (23,5)
1	52 (34,9)
2	28 (18,8)
3	20 (13,4)
≥ 4	14 (9,4)
ASA classification (%)	
ASA 2	36 (24,2)
ASA 3	104 (69,8)
ASA 4	9 (6,0)

Table 2. Type of fracture according different fracture classifications

	Intracapsular (n=16)	**Pertrochanteric (n=112)**	**Subtrochanteric (n=21)**
AO classification			
A1		40	
A2		65	
A3		7	21
B1	7		
B2	7		
B3	2		
Evans classification			
Type 1		13	
Type 2		21	
Type 3		13	
Type 4		34	
Type 5		31	
Reversed type			21
Pauwels classification			
Type 1	2		
Type 2	7		
Type 3	7		
Garden classification			
Type 1	5		
Type 2	3		
Type 3	6		
Type 4	2		

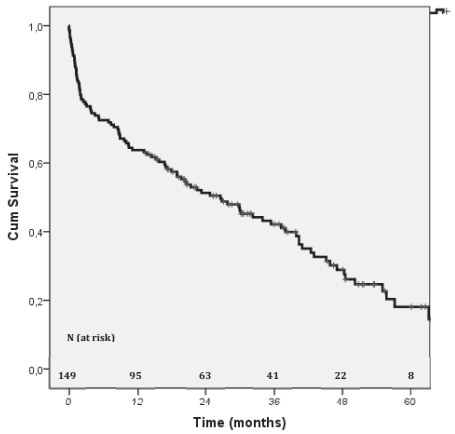

Figure 1. Overall survival in total group of patients.

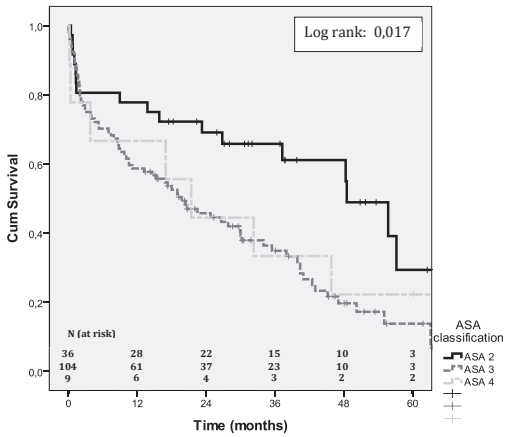

Figure 2. Survival according ASA classification.

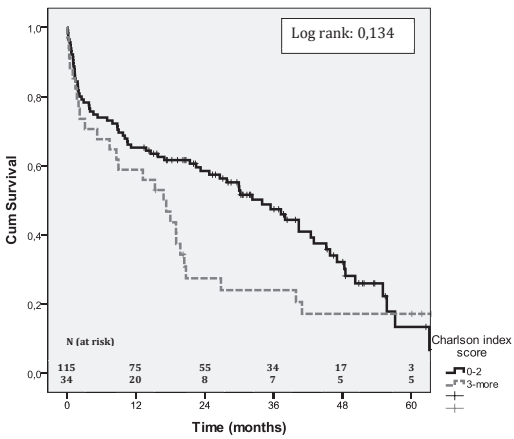

Figure 3. Survival according Charlson index score.

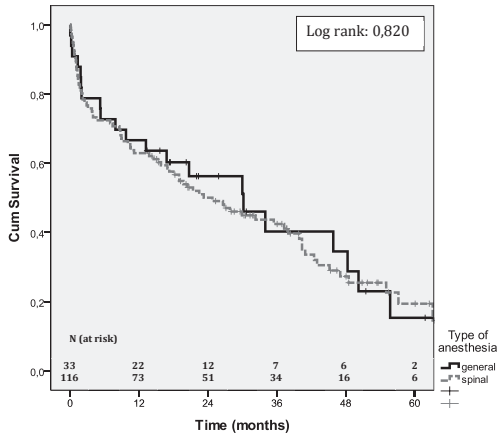

Figure 4. Survival according type of anesthesia.

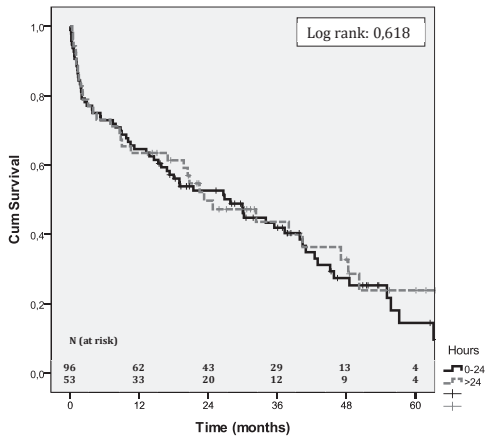

Figure 5. Survival according time between occurrence of hip fracture and surgery.

(P=0.011). The contribution of all these variables simultaneously, now also including the continuous variables age and length of hospital stay, to the Cox proportional hazards model was significant (P < 0.0005), the significant variables being ASA score, fully independent, length of hospital stay and age. The mortality rate ratio of ASA score 3 or 4 relatively to ASA score 2 was 1.9 (P = 0.017; 95 % CI: 1.1-3.3). Fully independent patients had a lower mortality rate than dependent patients (rate ratio 0.60; P= 0.027; 95 %CI: 0.38-0.94). A one-year age Increase resulted in a mortality rate ratio of 1.16 (P=0.001; 95 % CI: 1.06-1.26). A one-day longer hospital stay resulted in a mortality rate ratio of 1.03 (P=0.019; 95 % CI: 1.01-1.05). The P-values of the other variables in the model ranged from 0.36 to 0.73.

To determine the predictive value of these different parameters on short-term mortality we measured mortality rates in only the first three months, during which 34 deaths were observed. Univariate analyses using the log rank test showed that fully independent patients

had a lower short-term mortality rate (P=0.010) and that post-operative delirium was associated with a higher short-term mortality rate (P=0.019). Entering all variables simultaneously, now also including the continuous variables age and length of hospital stay, in the Cox proportional hazards model led to a significant effect on short-term mortality (P=0.013). The significant variables were age (P=0.013) and length of hospital stay (P=0.030). A 1-year age increase and a 1-day longer stay in hospital resulted in short-term mortality rate ratios of 1.19 (95 % CI: 1.04-1.37) and 1.03 (1.00-1.06), respectively. Fully independent patients had a lower short-term mortality (P=0.052; rate ratio 0.38; 95 % CI: 0.14-1.01). The effect of post-operative delirium was no longer significant (P=0.16) as it was confounded with length of hospital stay. P-values of the other variables in the model ranged from 0.46 to 0.98.

Postoperative delirium was diagnosed in 49 (33%) patients. Median length of hospital stay in patients with postoperative delirium was 13 days against 9 days in patients without delirium (P=0.049).

Preoperatively, place of residence was the patients' own home or a sheltered accommodation in 66 patients; only 20 (30%) of them returned to this place after surgery for hip fracture. The other 46 (70%) patients were discharged to a nursing or care home. Out of 39 patients preoperatively living in a nursing home, 16 (41%) returned to the nursing home after surgery and 23 (59%) were discharged tot a care home. All patients living in a care home preoperatively (N=31) were discharged to a care home after surgery. In summery, 69 of 136 (51%) patients were discharged to a place with more care after undergoing osteosynthesis for a hip fracture (Table 3).

Table 3. Place of residence before and after surgery for hip fracture

	Post-operative			
	Own home	Sheltered	Nursing home	Care home
Pre-operative				
Own Home (N=54)	16 (29,6%)	3 (5,6%)	8 (14,8%)	27 (50%)
Sheltered (N=12)	0	1 (8,3%)	4 (33,3%)	7 (58,3%)
Nursing home (N=39)	0	0	16 (41%)	23 (59%)
Care home (N=31)	0	0	0	31 (100%)

Regarding the consequences of a hip fracture on patient's mobility we found the following results. Preoperative mobility was fully independent in 49 patients, but after surgery 44 (90%) patients needed a walking aid/frame, four (8%) patients ended up in a wheelchair, and only 1 (2%) patient managed to walk fully independently. Seventy-five patients used a walking aid/frame before their fracture. Postoperatively, 53 (71%) of them were mobile with the same

walking aid/frame, whereas the other 22 (29%) patients ended up in a wheelchair. The 3 patients who were already in a wheelchair, remained as such after surgery. Thus, 70 of 124 (57%) patients were less mobile after undergoing osteosynthesis of a hip fracture. (Table 4)

Table 4. Patient's mobility before and after surgery for a hip fracture

	Post-operative			
	No aids	One aid	Walking frame	Wheelchair
Pre-operative				w
No aids (N=49)	1 (2%)	3 (6,1%)	41 (83,7%)	4 (8,2%)
One aid (N=6)	0	0	4 (66,7%)	2 (33,3%)
Walking frame (N=69)	0	0	49 (71%)	20 (29%)
Wheelchair (N=3)	0	0	0	3 (100%)

DISCUSSION

To our knowledge, this is the first study to describe the functional outcome and short-term and long-term mortality after osteosynthesis of a hip fracture in a large population of patients aged over 90 years. With the progressive increase in life expectancy and population growth, the incidence of hip fractures will increase in the near future.[20] Advanced age, male gender, previous hospitalization, comorbidity, and other factors are known to be associated with increased morbidity and mortality and poor functional results after hip fracture.[6,20] Yet, there is still no clear objective method for predicting the outcome of surgery in very elderly patients with hip fractures.

ASA classification and the CCI are both scoring systems for preoperative comorbidity. Burgos et al reported a relation between CCI and the development of serious complications during the hospital stay.[20] In our study population with patients aged 90 years or older, mortality rates in patients with higher ASA scores were significant higher in comparison to those with lower ASA scores. On the other hand, CCI was not found to be predictor for mortality. Earlier studies already described a nine times increased risk for mortality in patient with high ASA scores (3 or 4).[20,21] Therefore, ASA classification also seems the best predictive indicator for overall mortality after osteosynthesis of hip fractures in extremely elderly patients.

Because of the relative short life expectancy of extremely elderly patients it is interesting to look at the predictive value of risk factors on short-term mortality. An earlier study described exceptionally high mortality rates in the first 3 months after hip fracture.[22] Indeed, our study showed a mortality rate of 23% in the first three months after surgery. However, we could not find a clear relationship between CCI scores, ASA scores, type of anesthesia, or total preopera-

tive delay and the 3-months mortality rate. Given the fact that the total preoperative delay did also not influence the long-term mortality, this suggest that patient's general conditions can possibly be optimized before surgery. De Palma et al earlier described similar results with a preoperative delay of 48 hours.[23] They concluded that patients with comorbidity conditions requiring stabilization do not necessarily need to be treated within 48 hours.

Delirium is a common complication in elderly patients after hip fracture surgery and is associated with adverse outcomes, including longer length of hospital stay, greater rate of institutional placement, greater dependence on others, higher costs, delayed recovery, and increased mortality.[24] In our study, length of hospital stay was significantly longer in patients with delirium. A longer length of stay was associated with higher short-term mortality, adjusted for delirium and other variables. Vochteloo et al described an integrated hip fracture care pathway that included a Risk Model for Delirium (RD) score.[25] They concluded RD score was an accurate tool for identifying high-risk patients with poorer outcome regarding delirium incidence, length of hospital stay, and return to pre-fracture living situation.[25] Wagner et al found a small benefit of geriatric intervention in elderly patients operated on for a hip fracture, which was mainly demonstrated in improved and earlier detection of medical geriatric conditions such as anemia and delirium.[26] Because of the poorer outcome measurements in patients with postoperative delirium, it remains important to diagnose and treat a delirium in an early stage.

This study shows the loss of independency of extremely elderly persons after a hip fracture. Although many of these persons already have difficulties in walking and independent living, a large proportion of these patients are faced with definitive loss of independence.[5] More than half of the patients were discharged to a place with more care after undergoing osteosynthesis of a hip fracture and 57% of patients were less mobile after surgery. Fully independent patients had significant lower mortality rates. Maybe in some cases, conservative treatment can be an alternative to surgery. However, this decision should be based on the individual patient and depends on several factors. Quality of life is an important factor in this decision and therefore it's recommended to study quality of life in further research

CONCLUSIONS

As the general population is ageing, an increasing number of extremely elderly patients will suffer from hip fractures. Our study shows that short-term mortality rates in these patients are high and there is no clear predictive value for mortality. ASA classification is the best predictive value for overall mortality in these patients. Finally, there is loss of independency in a large proportion of these patients after undergoing osteosynthesis of a hip fracture.

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Chapter 8

General discussion and future perspectives

GENERAL DISCUSSION

From a medical perspective the demographic shift towards a population with more older people forces us to reconsider health outcome measurements related to surgical procedures. In the older population the results of surgical treatment of vascular and orthopaedic trauma related diseases are not straightforward. Adequate patient selection may be the key to improve treatment results of vascular and orthopaedic trauma related diseases in the elderly population balancing between the pros and contras of a surgical intervention.

Chapter 2 describes results from a retrospective study on patency rates of primary autologous radio-cephalic arteriovenous fistulae and brachio-cephalic arteriovenous fistulae in patients aged 75 years and older. The Dialysis Outcomes Quality Initiative recommends radio-cephalic arteriovenous fistulae before brachio-cephalic arteriovenous fistulae in all dialysis patients needing hemodialysis.[1,2,3] However, our study shows brachio-cephalic arteriovenous fistulae having a significant higher primary and assisted patency and also significant higher secondary patency rates at 1 and 2 years. Based on these results, we advocate placement of fistulae in the elbow in case of older people as a longer intervention-free and thrombosis-free interval time may offer clear benefits. Next to patency rates, another key outcome measure in the elderly is the Quality of life (QoL), which is increasingly being evaluated for other vascular interventions.[4] It is stated that elderly dialysis patients would be better able to deal with their disease and dialysis.[5,6] In this study, QoL of the older dialysis patient did not differ greatly when compared to the QoL of elderly persons from the general population and patients after peripheral bypass surgery, as we demonstrated.[7,8] Thus these elderly dialysis patients, in which survival was poor, seems to maintain a relative high QoL despite the discomforts of dialysis. A disadvantage of our study is the retrospective design, giving a bias in the measurement of QoL. A prospective trial is needed to determine QoL in these dialysis patients.

Another vascular procedure is bypass surgery, which is performed in critical limb ischemia. At the moment, little is known about the outcome of this treatment in elderly patients. The treatment of critical limb ischemia in elderly patients was examined in **chapter 3**. We analyzed treatment results of elderly patients with critical limb ischemia (Rutherford 4 or 5/6) and divided the study population in two age groups (70-79 and 80+). In patients aged 80 years or older, surgical revascularization resulted in a significant higher mortality rate, whereas primary conservative, endovascular treatment and amputation resulted in similar mortality in comparison with people aged 70-79 years. We conclude that surgical revascularization is a very high-risk procedure in patients aged 80 years and older with critical limb ischemia with a perioperative mortality of 22%. In contrast conservative management in these patients resulted in a perioperative mortality of 9%. Therefore, the surgeon should focus on careful patient selection when considering surgical revascularization in the very elderly. The definition of critical limb ischemia is important in this matter. Critical limb ischemia with limited

tissue loss or pain can be managed conservatively in the non-ambulant elderly, whereas severe tissue loss in patients with a vascular lesion unsuitable for endovascular treatment represents the other end of the spectrum. More attention should be paid to QoL in addition to surgical feasibilities. Patients with critical limb ischemia have poor health prospects and life expectancy, irrespective of treatment administered.[9] Randomized trials of health-related Quality of life after revascularization versus primary amputation are nonexistent and the available observational studies do not allow sound conclusions, due to small numbers and methodologic imperfections.[9] In this study, primary amputation in patients with critical limb ischemia resulted in better survival as compared to surgical revascularization. However, what this means for the quality of life in these patients is yet not clear. For this reason, recently a prospective study was started in the Amphia hospital, Breda, The Netherlands. This study focuses on the quality of life before, during and after treatment of critical limb ischemia in elderly patients.

In **Chapter 4** a review of the literature concerning treatment of AAA in elderly patients is presented in addition to our results on the elective treatment of abdominal aorta aneurysms (AAA) in elderly patients. Geisbusch et al. described that endovascular aneurysm repair (EVAR) in octogenarians had acceptable midterm survival rates and suggested that age should therefore not be an exclusion criteria for EVAR.[10,11] Also, in "high risk" patients EVAR for AAA was justified with a 2-year survival rate of 84%.[12] Our study demonstrates that mortality after endovascular treatment of AAA in patients aged 80 years and older was significantly higher compared to the younger group. Morphology of AAA was not described in our study and could have influenced this outcome. It may be argued that patients aged 80 years and older were treated with EVAR despite of more difficult morphology of AAA. These patients may present with more comorbidity and the outcome may be biased as EVAR is less invasive than OPEN repair, thus favouring a minimal invasive approach. This assumption is supported by the fact that a relative small number of patients aged 80 years and older underwent OPEN repair. Schlösser et al. reported a 1-year mortality rate after elective OPEN surgical AAA repair of 33% in patients aged 80-84 years and 54% in patients aged above 85 years.[13] In comparison, our study showed a 1-year mortality rate of 17% after elective EVAR in octogenarians. Therefore, EVAR in patients aged 80 years and older seems to have acceptable survival, despite the significantly higher mortality rate in comparison to younger patients. Conservative management of AAA was investigated and significantly higher mortality rates after conservative management of AAA were found as compared to EVAR or OPEN repair. However, after conservative management of AAA 38% of patients aged 80 years or older were still alive after 5-year follow up against 60% after EVAR and 87% OPEN repair. The definition of AAA is important in this matter and asymptomatic aneurysms of the aorta with diameters equal to or slightly larger than the treatment criteria can more easily be managed conservatively. One article of our review reported on the conservative management of AAA in "high risk" patients unfit for surgery and concluded that aneurysm rupture rate is

relatively high among conservatively treated patients unfit for surgery. In this conservative treated group of patients, 42% survived the operation of a ruptured AAA. Despite of the fact that conservative management of AAA results in higher mortality, it should be an option in patients with poor general health and significant comorbidities.

In **chapter** 5 we performed a secular trend analysis of all hospitalizations due to a pelvic fracture among older adults, using the National Medical Registration, 1986-2011, the Netherlands. The total number of hospitalizations due to a pelvic fracture increased from 887 in 1986 to 2,013 admissions in 2011 (127% increase). The overall age-adjusted incidence rate increased from 5.19 in 1986 to 7.14 per 10,000 population in 2011 (37.5% increase). The mean length of hospital stay decreased from 25.8 to 12.0 days between 1991 and 2011 (53.4% decrease). Absolute numbers and incidence rates of pelvic fractures are increasing among the older Dutch population. Attention on osteoporosis screening and prevention of falls in elderly remains important, in order to limit related healthcare costs in the future.

In **Chapter 6** our results of operative treatment for proximal fractures of the humerus in elderly patients (> 75 years) are presented. Sixty-four patients were treated surgically for a displaced proximal fracture of the humerus, 15 two-part, 32 three-part and 17 four-part fractures. Regarding the operative methods, overall good results were obtained with the modern locked plate osteosynthesis. Persistent pain and ADL-limitations were more present in more comminuted fractures (64% and 50% in patients with 4-part fractures vs 14% in patients with 2-part fractures). Especially in patients treated by locked compression plates, adequate pain reduction and functional recovery was achieved In the studied population, pain experience, ADL limitations and the overall functional outcome as measured by the DASH score, is significantly worse after hemiarthroplasty compared to internal fixation. In this study we conclude that it is safe and justifiable to perform osteosynthetic repair of a severely dislocated proximal humerus fracture in selected patients of 75 years and older. Surgery of the proximal humerus fracture might diminish pain and ADL limitations and potentially contribute to the preservation of an independent lifestyle.

Chapter 7 describes the outcome after osteosynthesis of hip fractures in nonagenarians. Short-term survival was 91% and 77% on 30-day and 3-months respectively. Long-term survival was 64%, 42% and 18% at 1-, 3- and 5 years after surgery. The overall one-year mortality rate associated with hip fracture is reported between 14% to 47%.[14,15] Following these numbers, it seems justified to perform surgery for a hip fracture in extremely elderly patients. In order to demonstrate predictive value of comorbidities for mortality patients were stratified according ASA and Charlson comorbidity index (CCI) score. Survival was significant better in patients with lower ASA score (P<0,05). The study further shows that short-term mortality rates in these patients are relatively high and there is no clear predictive value. ASA classification is the best predictive value for overall mortality in these patients. CCI score was not of predictive value for mortality. This study confirms the loss of independency of extremely elderly persons after a hip fracture. Although many of these persons already have

difficulties in walking and independent living, a large proportion of these patients are faced with definitive loss of independence. More than half of the patients were discharged to a place with more care after undergoing osteosynthesis of a hip fracture and 57% of patients were less mobile after surgery. These results are probably of influence on the quality of life in these patients and therefore further studies on the different aspects of quality of life are recommended.

FUTURE PERSPECTIVES

In these studies the presence of delirium was not examined. However, delirium is a serious comorbidity in the elderly population. It is well known that presence of a delirium results in a significantly higher morbidity and mortality after surgical treatment in general. Further studies on surgical treatment in the very elderly should pay attention to the presence of delirium to assess the influence on survival, morbidity and independency of these patients.

Nevertheless, a close cooperation between surgeon and geriatrician in the treatment of these patients is to recommend.

Other important outcome measurements that should get more attention in further studies of the elderly population are decubitus, nutrition and physical condition. Pre-operative nutrition level and physical condition of patients can seriously influence the outcome after surgical interventions. Decubitus is a common problem in (especially) older patients that can cause serious comorbidity, decline in quality of life and even loss of independency.

CONCLUSIONS

This thesis shows that the elderly population is a very specific group of patients whose treatment is not straightforward, but must be tailored to the individual patient. It remains difficult to express comorbidity in a specific score, and thereby predicting the risk of dying as a result of a certain operation. For the future, development of a better tool to assess mortality of surgical treatment is recommended. In general, the impact of surgical treatment on quality of life in these elderly patients needs more attention. In order to assess outcome of different treatment strategies, quality of life and general condition of patients must be taken into account.

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Chapter 9

Samenvatting, algemene discussie en toekomstperspectieven

ALGEMENE DISCUSSIE EN SAMENVATTING

De demografische verschuiving in het aantal ouderen zorgt voor een oudere behandelgroep. De chirurgische behandeling van vasculaire en trauma gerelateerde aandoeningen in deze oudere populatie is niet eenvoudig. Zorgvuldige patiëntselectie zou wel eens de sleutel kunnen zijn tot betere behandelresultaten van vasculaire en trauma gerelateerde aandoeningen binnen deze oudere bevolkingsgroep.

Hoofdstuk 2 beschrijft de resultaten uit onze retrospectieve studie naar patency waardes van primaire autologe radio-cefale arterioveneuze fistels en brachio-cefale arterioveneuze fistels bij patiënten van 75 jaar en ouder. De Dialysis Outcomes Quality Initiative adviseert het aanleggen van radio-cefale arterioveneuze fistels boven brachio-cefale arterioveneuze fistels in alle hemodialyse patiënten. [1,2,3] Echter, onze studie bij oudere patiënten toont aan dat brachio-cefale arterioveneuze fistels een significant hogere primaire en assisted patency hebben en tevens ook een significant hogere secondaire patency na 1 en 2 jaar. Gezien het langere interventie-vrije en trombose-vrije interval pleiten wij voor het aanleggen van een elleboogfistel bij deze oudere patiëntenpopulatie. Naast deze patency waardes, is de kwaliteit van leven binnen de ouderenzorg een steeds belangrijkere uitkomstmaat, welke ook steeds vaker wordt geëvalueerd bij andere vasculaire interventies. [4] Bejaarde dialyse patiënten zouden daarbij beter kunnen omgaan met hun ziekte en het dialyseren. [5,6] In deze studie, is er weinig verschil tussen de gemeten kwaliteit van leven van de oudere dialyse patiënt in vergelijking met de kwaliteit van leven gemeten bij ouderen uit de algemene populatie en patiënten na perifere bypass chirurgie, zoals enkele eerdere studies hebben aangetoond. [7,8] Dus deze populatie van oudere dialysepatiënten, waarin de overleving slecht is, lijkt een relatief hoge kwaliteit van leven te ervaren ondanks de ongemakken van dialyse. Het blijft echter moeilijk om de kwaliteit van leven retrospectief te meten en prospectief onderzoek is daarom ook nodig om de kwaliteit van leven beter te kunnen bepalen in deze dialysepatiënten.

Een andere vasculaire procedure is bypass chirurgie, hetgeen kan worden uitgevoerd in het geval van kritieke ischemie van de onderste extremiteit. Op dit moment is nog weinig bekend over de resultaten van deze behandeling bij ouderen. De behandeling van kritieke extremiteiten ischemie bij ouderen wordt beschreven in **hoofdstuk 3**. We analyseren de behandelresultaten bij oudere patiënten met kritieke ischemie van de onderste extremiteit (Rutherford 4 of 5/6) en verdelen de studie populatie in twee leeftijdsgroepen (70-79 en 80). Bij patiënten van 80 jaar of ouder resulteert bypass chirurgie in een significant hogere mortaliteit. Daarentegen leidt primaire conservatieve, endovasculaire behandeling en amputatie tot vergelijkbare sterfte binnen beide leeftijdsgroepen. We kunnen concluderen dat bypass chirurgie een zeer risicovolle procedure is bij patiënten van 80 jaar en ouder met kritieke ischemie met een perioperatieve sterfte (30-dagen mortaliteit) van 22 %. In vergelijking leidt conservatieve behandeling in deze patiënten tot een 30-dagen mortaliteit van 9 %.

De chirurg moet zich dus concentreren op een zorgvuldige patiëntselectie wanneer bypass chirurgie wordt overwogen bij de hoogbejaarden. De definitie van kritieke ischemie is hierbij wel van belang. Kritieke ischemie met een beperkte wonden of pijn kan vaak conservatief worden behandeld in de niet-ambulante ouderenzorg, terwijl in het geval van ernstige wonden met veel pijn bij patiënten met vasculaire laesies die niet geschikt zijn voor endovasculaire behandeling vaak chirurgische interventie is aangewezen. Kwaliteit van leven is een belangrijke uitkomst van de behandeling. Patiënten met kritieke ischemie hebben, ongeacht de gekozen behandeling, slechte vooruitzichten met betrekking tot gezondheid en levensverwachting. [9] Gerandomiseerde trials naar gezondheids-gerelateerde kwaliteit van leven na chirurgische revascularisatie versus kwaliteit van leven na primaire amputatie zijn er nog niet en de beschikbare observatiestudies geven geen duidelijke uitkomsten, als gevolg van kleine aantallen en methodologische onvolkomenheden. [9] In deze studie, resulteert primaire amputatie bij patiënten met kritieke ischemie in betere overleving in vergelijking tot wanneer er chirurgische revascularisatie wordt verricht. Echter, wat dit betekent voor de kwaliteit van leven van deze patiënten is nog niet duidelijk. Om die reden is onlangs een prospectieve studie gestart in het Amphia ziekenhuis, Breda. Deze studie richt zich op de kwaliteit van leven voor, tijdens en na de behandeling van kritieke ischemie van de onderste extremiteit bij ouderen.

In **hoofdstuk 4** worden de resultaten van electieve behandeling van een aneurysma van de abdominale aorta (AAA) bij ouderen beschreven. Tevens is er een overzicht van de literatuur over de behandeling van AAA in oudere patiënten. Geisbusch et al. beschreven dat de endovasculaire behandeling van een abdominaal aneurysma (EVAR) bij tachtigjarigen aanvaardbare overlevingsgetallen liet zien en suggereerde dat leeftijd daarom geen exclusiecriteria mag zijn voor EVAR. [10,11] Ook in "hoog risico" patiënten was EVAR gerechtvaardigd met een 2-jaars overleving van 84 % . [12] Onze studie toont aan dat de mortaliteit na endovasculaire behandeling van een AAA bij patiënten ouder dan 80 jaar significant hoger was in vergelijking met de jongere groep. Morfologie van een AAA is echter niet beschreven in onze studie en zou invloed kunnen hebben gehad op dit resultaat. Het is namelijk mogelijk dat patiënten van 80 jaar en ouder werden behandeld met EVAR ondanks morfologische kenmerken van een AAA die deze procedure lastiger maken. Er kan een selectie bias zijn opgetreden als deze patiënten met meer co morbiditeit werden behandeld middels EVAR, omdat dit een minder invasieve ingreep is. Deze veronderstelling wordt ondersteund door het feit dat een relatief klein aantal patiënten van 80 jaar en ouder een open procedure van een AAA ondergingen. Schlösser et al. beschreven een 1-jaars mortaliteit van 33% na electieve open behandeling van een AAA bij patiënten van 80 tot 84 jaar en 54% bij patiënten ouder dan 85 jaar. [13] Ter vergelijking, is de 1-jaars mortaliteit na electieve EVAR bij tachtigjarigen in onze studie 17%. Gezien deze verschillen in mortaliteitpercentages lijkt het verrichten van een EVAR bij patiënten ouder dan 80 jaar aanvaardbaar, ondanks de aanzienlijk hogere sterfte in vergelijking met jongere patiënten. Wanneer de conservatieve behandeling van een AAA wordt onderzocht,

zien we aanzienlijk hogere sterftecijfers na conservatieve behandeling van een AAA in vergelijking met mortaliteit na EVAR of open behandeling. De 5-jaars overleving van conservatieve behandeling van een AAA bij patiënten ouder dan 80 jaar was 38% in vergelijking met 60% na EVAR en 87% na open behandeling. De definitie van een AAA is hierbij belangrijk, omdat een asymptomatische aneurysma van de aorta met een diameter gelijk aan of iets groter dan de behandeling criteria gemakkelijker conservatief behandeld kan worden. Een artikel uit onze review beschrijft de conservatieve behandeling van een AAA in "hoog risico" patiënten die niet fit genoeg waren om een chirurgische behandeling te ondergaan. Er wordt geconcludeerd de ruptuurkans van een AAA binnen deze conservatief behandelde patiëntengroep relatief hoog ligt, maar dat daarentegen 42 procent van deze patiënten de operatie van het geruptureerde aneurysma uiteindelijk hebben overleeft. Ondanks het feit dat conservatieve behandeling van een AAA resulteert in hogere mortaliteit, zou het dus een optie kunnen zijn bij patiënten met een slechte algemene gezondheid en belangrijke co morbiditeit.

In **hoofdstuk 5** voeren we een trend analyse uit van alle ziekenhuisopnames als gevolg van een bekkenfractuur bij oudere patiënten. We maken hierbij gebruik van de Nationale Medische Registratie, 1986-2011, Nederland. Het totaal aantal ziekenhuisopnames ten gevolge van een bekkenfractuur steeg van 887 in 1986 naar 2.013 opnames in 2011 (127% stijging). De totale voor leeftijd gecorrigeerde incidentie steeg van 5,19 in 1986 tot 7,14 per 10.000 inwoners in 2011 (37,5 % toename). De gemiddelde duur van een ziekenhuisverblijf is tussen 1991 en 2011 afgenomen tot 12,0 dagen (53.4% afname). Absolute aantallen en incidentie van bekkenfracturen nemen toe bij de oudere Nederlandse bevolking. Aandacht voor osteoporose screening en preventie van vallen bij ouderen blijft belangrijk om gerelateerde kosten voor de gezondheidszorg in de toekomst te reduceren.

In **hoofdstuk 6** worden de resultaten van operatieve behandeling van proximale humerusfracturen bij oudere patiënten (> 75 jaar) besproken. Vierenzestig patiënten werden behandeld voor een gedisloceerde proximale humerusfractuur, waarvan 15 two-part, 32 three-part en 17 four-part fracturen. Er werden goede resultaten bereikt met de moderne vergrendelplaat osteosynthese. Persisterende pijnklachten en ADL-beperkingen zijn meer aanwezig in meer communitieve fracturen (64% en 50% bij patiënten met een 4-part fractuur versus 14% bij patiënten met een 2-part fractuur). Met name bij de patiënten behandeld met open repositie en interne fixatie middels vergrendelde compressieplaten werd adequate pijnvermindering en functioneel herstel bereikt In de bestudeerde populatie. Pijn beleving, ADL beperkingen en het algehele functionele resultaat zoals gemeten met de DASH score waren beduidend slechter na een schouderkopprothese in vergelijking met open repositie en interne fixatie. Deze studie concludeert dat het veilig en verantwoord is om een osteosynthese van een ernstig gedisloceerde proximale humerusfractuur te verrichtten bij geselecteerde patiënten van 75 jaar en ouder. Chirurgische behandeling van een proximale humerusfractuur kan zorgen voor verminderde pijn en ADL beperking en mogelijk bijdragen tot de instandhouding van een onafhankelijk leven.

Hoofdstuk 7 beschrijft het resultaat na osteosynthese van heupfracturen bij 90-plussers. Korte-termijn overleving was respectievelijk 91% en 77% op 30-dagen en 3-maanden. Lange termijn overleving was respectievelijk 64 %, 42% en 18% op 1-, 3- en 5 jaar na operatie. De totale jaarlijkse sterfte geassocieerd aan een heupfractuur wordt beschreven tussen de 14% en 47%. [14,15] Aan de hand van deze getallen lijkt chirurgie gerechtvaardigd bij hoogbejaarde patiënten met een heupfractuur. Om de voorspellende waarden van diverse co mobiliteiten te bepalen werden patiënten gescoord volgens de ASA en Charlson comorbidity index (CCI) score. De overleving was significant beter in patiënten met lagere ASA score ($P<0,05$). Uit de studie blijkt verder dat de korte-termijn sterfte in deze patiënten relatief hoog is en dat er geen duidelijk voorspellende waarde is voor sterfte. ASA classificatie is de beste voorspellende waarde voor de totale sterfte in deze patiënten. CCI score was niet van voorspellende waarde voor de sterfte. Deze studie toont aan dat een heupfractuur bij hoogbejaarde personen grote impact heeft op de mate van onafhankelijk van deze populatie. Hoewel veel van deze personen al moeilijkheden ervaren met lopen en hun zelfstandigheid, wordt een groot deel van deze patiënten geconfronteerd met een definitief verlies van hun zelfstandigheid. Meer dan de helft van de patiënten werden na het ondergaan van osteosynthese een heupfractuur ontslagen naar een instelling met meer zorg en 57% van de patiënten waren minder mobiel. Deze resultaten hebben waarschijnlijk invloed op de kwaliteit van leven van deze patiënten, maar in welke mate zal verder onderzoek hiernaar moeten aantonen.

TOEKOMSTPERSPECTIEVEN

In deze onderzoeken is de incidentie van een delier niet onderzocht. Echter, delier is een ernstige co morbiditeit voor de oudere patiëntenpopulatie. Het is bekend dat de aanwezigheid van delier resulteert in een beduidend hogere morbiditeit en mortaliteit na chirurgische behandeling in het algemeen. Verdere studies naar de chirurgische behandeling van ouderen zullen aandacht moeten besteden aan de aanwezigheid van delier ter beoordeling van de invloed hiervan op de overleving, morbiditeit en mate van zelfstandigheid van deze patiënten. Een nauwe samenwerking tussen chirurg en geriater in de behandeling van deze patiënten wordt aangeraden. Andere belangrijke uitkomstmaten die meer aandacht verdienen in toekomstige studies met betrekking tot ouderen zijn decubitus, voeding en algemene fysieke conditie. Preoperatieve voedingstoestand en de fysieke conditie van patiënten kunnen van grote invloed zijn op de uitkomst van chirurgische behandelingen. Decubitus is een veelvoorkomend probleem in (vooral) oudere patiënten, hetgeen kan leiden tot ernstige co morbiditeit, achteruitgang in kwaliteit van leven en zelfs verlies van zelfstandigheid.

CONCLUSIE

Dit proefschrift toont aan dat de oudere patiëntenpopulatie een zeer specifieke groep patiënten is, waarvan de behandeling niet eenvoudig is en moet worden afgestemd op de individuele patiënt. Het blijft moeilijk om co morbiditeit uit te drukken in een specifieke score en zodoende te voorspellen wat het sterfterisico is van een bepaalde behandeling. De ontwikkeling van een beter instrument voor het inschatten van het sterfterisico van chirurgische behandeling is aanbevolen. Verder is er in het algemeen meer aandacht nodig voor het effect van chirurgische behandeling op kwaliteit van leven van de oudere patiëntpopulatie. Om resultaten van verschillende behandelingsstrategieën te kunnen beoordelen, moet aandacht zijn voor de kwaliteit van leven en de algemene conditie van patiënten.

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Chapter 10

List of publications

List of abbreviations

Dankwoord

Curriculum vitae

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LIST OF ABBREVIATIONS

AAA:	Abdominal Aortic Aneurysm
RCAVF:	Radio-Cephalic ArterioVenous Fistulae
BCAVF:	Brachio-Cephalic ArterioVenous Fistulae
AVF:	ArterioVenous Fistulae
DOQI:	The Dialysis Outcomes Quality Initiative
QoL:	Quality of Life
HD:	HemoDialysis
WHO:	World Health Organization
ESRD:	End-Stage Renal Disease
CLI:	Critical Limb Ischemia
PAD:	Peripheral Artery Disease
AFS:	Amputation Free Survival
TASC:	Trans-Atlantic interSociety Consensus
MRA:	Magnetic Resonance Angiography
OPEN:	Open abdominal repair
EVAR:	EndoVascular Aortic Repair
ASA:	American Society of Anaesthesiologists
ASN:	Association of Surgeons of the Netherlands
PAC:	Percentual Annual Change
LOS:	Length of Hospital Stay
DASH:	Disability of Arm, Shoulder and Hand
ADL:	Activities of Daily Life
ORIF:	Open Reduction and Internal Fixation
CCI:	Charlson Comorbidity Index
DHS:	Dynamic Hip Screw
DOS:	Delirium Observation Screening
RD:	Risk Model for Delirium

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CURRICULUM VITAE

Kevin de Leur was born on December 18th 1983 in Sliedrecht. He graduated the Athenaeum at the Willem de Zwijger College in Papendrecht in 2002. In this year, he started studying Medicine at the Erasmus University of Rotterdam. After graduation in 2009, he started as a surgical resident at the Amphia hospital in Breda. During this residency he started research under supervision of dr. L. van der Laan, Amphia hospital Breda and Prof. dr. J.N.M. IJzermans, Erasmus University Rotterdam. This finally results in this thesis.

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