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The Effect of Frailty on Outcome After Vascular Surgery

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Objectives: Frailty is a state of increased vulnerability and is a stronger predictor for post-operative outcome than age alone. The aim of this study was to determine whether frailty is associated with adverse 30 day outcome in vascular surgery patients.
Methods: This was a prospective cohort study. All electively operated vascular surgery patients between March 2010 and October 2017 ($n = 1201$), aged $\geq$ 60 years were evaluated prospectively. Exclusion criteria were arteriovenous access surgery, percutaneous interventions and minor amputations, resulting in 825 patients for further analysis whereas 195 had incomplete data on Groningen Frailty Indicator (GFI) and were excluded. Frailty was measured using the GFI, a screening tool covering 16 items in the domains of functioning. Patients with a total score of $\geq$4 were classified as frail. The primary outcome parameter was 30 day morbidity (based on the Comprehensive Complication Index). Secondary outcome measures were 30 day mortality, hospital readmission, and type of care facility after discharge. Outcomes were adjusted for sex, body mass index, smoking status, hypertension, Charlson Comorbidity Index, and type of intervention.
Results: There was an unequal sex distribution (77.6% male). The mean age was 72.1 years. One hundred and eighty-four patients (22.3%) were considered frail. The mean Comprehensive Complication Index was 8.5. Frail patients had a significantly higher Comprehensive Complication Index (3.7 point increase, $p = .005$). Patients with impaired cognition and reduced psychosocial condition, two domains of the GFI, had a significantly higher Comprehensive Complication Index. Also, the 30 day mortality rate was higher in frail patients (2.7 point increase; $p = .05$), and they were discharged to a care facility more often (7.7 point increase; $p < .001$). There was no significant difference in readmission rates between frail and non-frail patients.
Conclusions: Frailty is associated with a higher risk of post-operative complications and discharge to a nursing home after vascular surgery. Some frailty domains (mobility, nutrition, cognition and psychosocial condition) appear to have a more pronounced impact.

Keywords: Frailty, Elderly, Complications, Mortality
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INTRODUCTION

The number of people aged over 60 is increasing rapidly worldwide, with percentages rising from 20% to 30% between 2015 and 2050 in North America, and 25% to almost 35% in Europe.[1] Treating elderly patients comes with specific challenges because of age related physiological changes that include increased risk of cardiovascular disease, multiple morbidities and various geriatric syndromes, resulting in an increased risk of both short and long term complications.[2—4] In recent years frailty has become an important prognostic indicator for surgical outcome. Frailty is a syndrome defined as a state of increased vulnerability due to a decline in reserve and function, resulting in a decreased ability to cope with physiological stressors of decreasing magnitude.[5] Although it is common among older persons, age and frailty are considered two different entities. Frailty has been proven to be a stronger predictor for post-operative outcome than chronological age alone, and an independent risk factor for impaired outcome after major surgery.[6—12] In addition, recent studies show increased levels of frailty in vascular surgery patients compared with other types of surgery due to an overlap with cardiovascular disease.[13—15] A number of scoring tools have been developed and validated for various patient groups in order to determine the prevalence and severity of frailty, and identify at which point patients are at increased risk of an aberrant post-operative course. Although many scoring tools have similarities in risk factors, there is currently no single universally accepted method to measure frailty.[16—18] The aim of this prospective cohort study was to determine the influence of frailty on short term outcome after vascular surgery, with an emphasis on the specific domains of this multifactorial syndrome.

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MATERIALS AND METHODS

Design of the study

This single centre, prospective, observational study was conducted at the University Medical Centre Groningen, a tertiary referral teaching hospital. A total of 1201 consecutive electively operated vascular surgery patients were prospectively included between March 2010 and October 2017 and subsequently analysed. Since the incidence of frailty is much lower in younger patients the age of participants for this analysis was limited to ≥60 years to identify those items of frailty with the most impact on outcome.[19,20] Inclusion criteria were patients undergoing open or endovascular thoracic, aortic, fenestrated, iliac, and popliteal procedures, carotid surgery, peripheral bypass surgery, and elective major limb amputation surgery (transfemoral, through knee disarticulation, and transtibial). Exclusion criteria were patients undergoing arteriovenous access surgery, percutaneous transluminal angioplasty interventions (including coil embolisation), and minor amputations (forefoot amputation, digit and wound revisions). After exclusion, 825 patients formed the basis for further analysis in this study and all patients gave informed consent to participate. For this study the Medical Ethics Institutional Review Board granted dispensation from the Medical Research Involving Human Subjects Act (WMO) obligation (registration nr METC 2016/322). Patient data were processed and electronically stored according to the declaration of Helsinki — Ethical principles for medical research involving human subjects.

Assessment of frailty

Frailty was measured using the Groningen Frailty Indicator (GFI).[21–25] The GFI was obtained at the outpatient clinic by specially trained nurses. The feasibility, sensitivity, and specificity of the GFI had previously been tested in a pilot study among vascular surgery patients.[26] In short, the GFI consists of 16 items, classified into eight different groups, consistent with the domains of functioning: 1. mobility (0—4 points), 2. vision (0—1 point), 3. hearing impairment (0—1 point), 4. nutritional status (0—1 point) 5. comorbidity (0—1 point) 6. cognition (0—1 point) 6b. history of delirium (0—1 point) 7. psychosocial condition (0—4 points) and 8. physical fitness (0—1 point) (Table 1). Patients with a score of 4 or more were classified as frail. For this study both the total score and the individual domains were evaluated to determine the difference in composition between frail and non-frail patients.

Outcome parameters

The primary outcome parameter was 30 day morbidity, as measured by the Comprehensive Complication Index. Complications were first classified according to the Clavien—Dindo method. Grade I includes any deviation from the normal post-operative course, without the need for any type of treatment. Grade II includes complications requiring pharmacological treatment. Grade III includes complications requiring surgical, endoscopic, or radiological intervention under local/regional anaesthesia (IIIa) or under general

Table 1. The Groningen Frailty Indicator[26] to assess patient frailty (defined as a score ≥ 4)

Domains and items	Yes	No
Mobility (can the patient perform any of the following independently? use of tools like walking sticks, wheelchair or walker being allowed)		
1. Go shopping	0	1
2. Walk around outside	0	1
3. Dressing and undressing	0	1
4. Toilet visit	0	1
Vision		
5. Does the patient experience problems in daily life by poor vision	1	0
Hearing		
6. Does the patient experience problems in daily life by poor hearing	1	0
Nutrition		
7. Has the patient involuntarily lost weight (> 6 kg) in the past 6 months (or > 3 kg in the one month)	1	0
Comorbidity		
8. Does the patient currently use four or more different types of medication?	1	0
Cognition		
9. Does the patient currently have complaints about his memory (or have a history of dementia)	1	0
10. Does the patient have a history of post-operative delirium (POD)	1	0
Psychosocial		
11. Does the patient sometimes experience emptiness around him?	1	0
12. Does the patient sometimes miss people around him?	1	0
13. Does the patient sometimes feel abandoned?	1	0
14. Has the patient recently felt sad or depressed?	1	0
15. Has the patient recently felt nervous or anxious?	1	0
Physical fitness		
16. How would the patient grade his or her physical fitness (0—10; ranging from very bad to good) 0—6 = 1, 7—10 = 0		

A score of four or more is classified as frail.

anaesthesia (IIIb). Grade IV includes life threatening complications; single organ (IVa) or multi-organ (IVb); and grade V, death. Whereas in the original Clavien–Dindo classification the most severe complication was scored, the Comprehensive Complication Index accumulates all post-operative complications, weighted for their severity. The Comprehensive Complication Index is proven to be more sensitive than other complication indices.[27,28] Secondary outcome measures were 30 day mortality (including in hospital mortality), hospital readmission (including readmission to the intensive care unit [ICU]), and type of care facility after discharge. Hospital readmission was defined as any hospital readmission within 30 days. When a surgical complication occurred, patients were readmitted to the hospital for treatment or observation.

Data collected pre-operatively included age (years), sex, body mass index (BMI; weight in kg/height in metres squared), medical history, American Society of Anaesthesiologists (ASA) score, smoking status (y/n) and laboratory tests (haemoglobin level (Hb) (g/dL), C reactive protein (CRP) (mg/L), leucocyte count (10^9/L), and estimated glomerular filtration rate (eGFR) (mL/min $\times$ 1.73 m^2)). Comorbidity was determined by the Charlson Comorbidity Index, a weighted score that predicts the one year mortality of patients based on medical condition and age.[29] To calculate the Charlson Comorbidity Index, the calculator developed by Hall et al. was used.[30] Data collected intra-operatively included type of surgery, duration of surgery (minutes), type of anaesthesia, and blood loss (mL). Data collected post-operatively included hospital length of stay (HLOS) (days), ICU admission (y/n), and type of care facility after discharge.

Statistical analysis

Categorical variables are presented as numbers and percentages. Continuous variables are presented as mean $\pm$ standard deviation (SD) for normally distributed variables and as median $\pm$ interquartile range (IQR) for skewed variables. Multiple imputation was used to account for missing data (Table 2). These imputations were analysed one at a time, pooling the results using Rubin's rules.[31] To perform multiple imputation, the following predictors were used: age, sex, BMI, smoking status, Charlson Comorbidity Index, ASA classification, hypertension, diabetes mellitus, cerebrovascular disease, chronic obstructive pulmonary disease, all the items of the GFI, Hb, CRP, leucocyte count, eGFR, type of procedure, type of anaesthesia, duration of surgery, post-operative morbidity/mortality, readmission to the hospital, and care facility after discharge. To analyse the relationship between frailty and Comprehensive Complication Index a linear regression model was used. Binary logistic regression was used to analyse the association between frailty and hospital readmission, type of care facility after discharge, and mortality. Besides the crude analyses, two adjusted analyses were conducted: model 1 (†) adjusted for demographics (sex, BMI and smoking status), model 2 (§) adjusted for Charlson Comorbidity Index, type of intervention and variables from model 1. In additional analyses, interaction terms between frailty and the covariates age, sex, and Charlson Comorbidity Index were added to the fully adjusted model to assess whether the relation between frailty and the above mentioned outcomes varied across different levels of covariates. A p value $< .05$ was considered statistically significant. In exploratory analyses the association of the individual domains of the GFI with the outcome parameters were examined. All these analyses were adjusted for demographics, Charlson Comorbidity Index, and hypertension. All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS 22.0, SPSS, Chicago, IL, USA).

RESULTS

Baseline characteristics

Patient characteristics and demographic data are summarised in Table 2. One hundred and ninety-five patients (23.6%) had missing items on the GFI, with most (90.2%) having only one item missing. Baseline characteristics are stated only for those patients with a complete GFI. With $\geq$4 as total score, 184 patients (22.3%) were considered frail.

Morbidity

During hospital admission 269 patients (32.6%) had one or more complications. The mean Comprehensive Complication Index for the total cohort was 8.5 $\pm$ 17.0. Fifteen patients (1.8%) died during hospital stay. Patients with a GFI score $\geq$4 had a significantly higher Comprehensive Complication Index in model 2 (§) (Table 3). Frailty resulted in a 3.7 point increase in the Comprehensive Complication Index (95% CI 1.1–6.3, $p = .005$). Age, sex and Charlson Comorbidity Index did not change this relationship. Regarding the subdomains of frailty, patients with impaired cognition (memory loss or dementia symptoms) had a significantly higher Comprehensive Complication Index (6.1 point increase, 95% CI 1.2–11.0, $p = .02$). Patients with a reduced psychosocial condition had a 1.1 point increase (95% CI 0.2–2.0, $p = .01$).

Thirty day mortality. The 30 day mortality for the entire cohort was 2.3% ($n = 19$). Frailty was significantly associated with 30 day mortality in model 2 (§) (OR = 2.7, 95% CI 1.0–7.3, $p = .05$). (Table 4) Age, sex, and Charlson Comorbidity Index did not change the relationship between frailty and 30 day mortality. There were no individual frailty domains significantly associated with 30 day mortality.

Hospital readmission <30 days (including ICU). Forty-nine patients (5.9%) were readmitted to the hospital within 30 days. There was no statistically significant difference between patients with a GFI $<$4 and those with a GFI $\geq$4 (OR 1.4, 95% CI 0.8–2.7, $p = .27$) (Table 5). The effect of frailty on hospital readmission increased with a higher Charlson Comorbidity Index (positive sign of interaction term, $p = .03$). There were no individual subdomains of frailty that had an influence on the risk of readmission.

Table 2. Baseline characteristics of 630 vascular patients being assessed regarding pre-operative frailty using the Groningen Frailty Indicator (GFI)

Parameter	Non frail (GFI < 4) (n = 446)	Frail (GFI ≥ 4) (n = 184)	p value	Missing n (%)
Age – y	71.8 ± 6.8	73.2 ± 7.8	.03	0
Sex – male	365 (81.8)	121 (65.8)	<.001	0
BMI – kg/m^2	27.1 ± 4.3	26.8 ± 4.6	.5	8 (1.0)
Smoking status – n (%)				
Never	149 (33.4)	66 (35.9)	.52	19 (2.3)
History	289 (64.8)	113 (61.4)	.52	
Current	131 (29.3)	58 (31.5)	.57	
Charlson Comorbidity Index[‡]	5.2 ± 1.6	5.8 ± 1.9	<.001	0
ASA ≥ 3 – n (%)	232 (52.0)	137 (74.5)	<.001	0
Hypertension – n (%)	261 (58.5)	116 (63.0)	.33	0
Diabetes mellitus – n (%)	93 (2.1)	53 (28.8)	.04	0
Cerebrovascular disease – n (%)	152 (34.1)	79 (42.9)	.04	0
COPD – n (%)	56 (12.6)	43 (23.4)	.001	0
Hemoglobin level – g/dL	8.6 ± 1.0	8.0 ± 1.2	<.001	13 (1.6)
CRP – mg/L	5.0 (2.6–8.0)	5.8 (4.0–17.0)	<.001	158 (19.1)
Leucocyte count – × 10^9/L	8.1 ± 2.2	8.5 ± 2.7	.08	155 (18.8)
eGFR – mL/min/1.73 m^2	70.7 ± 22.9	66.4 ± 27.1	.06	7 (0.8)
Type of procedure – n (%)				
Carotid surgery	115 (25.8)	44 (23.9)	.69	0
Open aortic surgery	72 (16.1)	21 (11.4)	.14	
Endovascular procedures	159 (35.7)	50 (27.2)	.04	
Peripheral bypass surgery	81 (18.2)	35 (19.0)	.82	
Amputation surgery	19 (4.2)	34 (18.5)	<.001	
General anaesthesia – n (%)	356 (79.8)	134 (73.2)	.07	0
Duration of procedure – min	193.3 ± 95.8	180.3 ± 115.9	.15	0
Blood loss during procedure – mL	72.5 (0.0–500.0)	100 (0.0–400.0)	.98	170 (20.6)

Data are presented as mean ± standard deviation or median (interquartile range) unless indicated otherwise. ASA = American Society of Anaesthesiologists score; BMI = body mass index; COPD = chronic obstructive pulmonary disease; CRP = C reactive protein; eGFR = estimated glomerular filtration rate.
‡ Charlson Comorbidity Index (predicts one year mortality based on age and comorbidities; range 0–19).

Table 3. The effect of frailty (defined as a GFI score ≥ 4) and its individual function domains on 30 day morbidity after a vascular procedure: Analysis of 630 patients

	Odds ratio (95% confidence interval)	p
Frail (crude analysis)	3.8 (1.2–6.3)	.004
Frail (primary adjustment model)[†]	3.8 (1.2–6.3)	.004
Frail (secondary adjustment model)[§]	3.7 (1.1–6.3)	.005
Mobility[§]	1.0 (–0.3–2.2)	.13
Vision[§]	3.6 (–1.0–8.2)	.12
Hearing[§]	–0.6 (–3.7–2.5)	.70
Nutrition[§]	–0.9 (–5.1–3.3)	.67
Comorbidity[§]	0.7 (–2.1–3.6)	.60
Cognition[§]	6.1 (1.2–11.0)	.02
History of delirium[§]	3.1 (–0.9–7.2)	.13
Psychosocial[§]	1.1 (0.2–2.0)	.01
Physical fitness[§]	1.4 (–0.9–3.7)	.22

Morbidity was measured by the Comprehensive Complication Index, which is based on the Clavien-Dindo method. Scores range from 0 (no complication) to 100 (dead). GFI = Groningen Frailty Indicator.
† Outcome adjusted for sex, BMI (body mass index) and smoking status.
§ Outcome adjusted for sex, BMI, smoking status, Charlson Comorbidity Index and type of intervention.

Table 4. The effect of frailty (defined as a GFI score ≥ 4) and its individual function domains on 30 day mortality after a vascular procedure: Analysis of 630 patients

	Odds ratio (95% confidence interval)	p
Frail (crude analysis)	2.7 (1.1–6.6)	.04
Frail (primary adjustment model)[†]	2.7 (1.0–6.9)	.04
Frail (secondary adjustment model)[§]	2.7 (1.0–7.3)	.05
Mobility[§]	1.2 (0.7–2.0)	.55
Vision[§]	1.7 (0.4–7.0)	.43
Hearing[§]	1.5 (0.5–5.0)	.47
Nutrition[§]	1.3 (0.3–6.2)	.76
Comorbidity[§]	1.1 (0.3–3.6)	.92
Cognition[§]	2.6 (0.6–10.6)	.19
History of delirium[§]	1.1 (0.2–5.5)	.92
Psychosocial[§]	1.1 (0.8–1.5)	.68
Physical fitness[§]	1.3 (0.5–3.6)	.54

GFI = Groningen Frailty Indicator.
† Outcome adjusted for sex, BMI (body mass index) and smoking status.
§ Outcome adjusted for sex, BMI, smoking status, Charlson Comorbidity Index and type of intervention.

Type of care facility after discharge

The majority of patients (91.4%) could return to their own homes after discharge. Thirty-one patients (3.8%) were already living in a nursing home prior to surgery, and another 25 patients (3.0%) were discharged to a residential care facility either temporarily or permanently. Frailty was significantly associated with discharge to a care facility (OR = 7.7, 95% CI 2.6–22.9, $p < .001$). Age, sex, and Charlson Comorbidity Index had did not change this relationship. The subdomains ‘mobility’, ‘nutrition’, ‘cognition’, ‘history of delirium’, and ‘psychosocial condition’ were all significantly associated with higher risk of discharge to a care facility (Table 6).

DISCUSSION

This study shows that frailty has a strong association with various adverse outcomes after vascular surgery. Although previous studies have shown that a number of frailty characteristics can predict morbidity and mortality, this study is the largest prospective cohort study focusing on both frailty as a multidimensional impairment and the individual domains and characteristics of frailty.

In recent years it has become clear that frailty is a risk factor for impaired outcome after surgery. Identifying patients at risk is an important step in the decision making process of whether a patient would benefit from an intervention. It is essential to determine which specific aspects of frailty contribute to poor outcomes, as some of these aspects are reversible and could possibly be optimised pre-operatively. Implementing a standardised management protocol including frailty specific anaesthetic plans, clarified goals of care identified in the pre-operative setting, and an improved post-operative setting and management can result in decreased 30 day and one year mortality rates.[32]

Table 5. The effect of frailty (defined as a GFI score ≥ 4) and its individual function domains on risk of hospital re-admission from home within 30 days after a vascular procedure: Analysis of 630 patients

	Odds ratio (95% confidence interval)	*p*
Frail (crude analysis)	1.7 (1.0–3.2)	.07
Frail (primary adjustment model)[†]	1.7 (0.9–3.1)	.09
Frail (secondary adjustment model)[§]	1.4 (0.8–2.7)	.27
Mobility[§]	1.2 (1.0–1.4)	.14
Vision[§]	1.7 (0.7–4.4)	.24
Hearing[§]	1.2 (0.6–2.5)	.68
Nutrition[§]	1.4 (0.6–3.6)	.45
Comorbidity[§]	1.4 (0.6–3.2)	.49
Cognition[§]	2.0 (0.7–5.6)	.21
History of delirium[§]	1.6 (0.7–3.9)	.26
Psychosocial[§]	1.1 (0.8–1.3)	.63
Physical fitness[§]	1.5 (0.8–2.8)	.26

Hospital re-admissions included re-admissions to the intensive care unit. GFI = Groningen Frailty Indicator.
[†] Outcome adjusted for sex, BMI (body mass index) and smoking status.
[§] Outcome adjusted for sex, BMI, smoking status, Charlson Comorbidity Index and type of intervention.

Table 6. The effect of frailty (defined as a GFI score ≥ 4) and its individual function domains on risk of being discharged to a care facility after a vascular procedure: Analysis of 630 patients

	Odds ratio (95% confidence interval)	*p* value
Frail (crude analysis)	9.4 (3.4–25.9)	<.001
Frail (primary adjustment model)[†]	9.6 (3.4–27.0)	<.001
Frail (secondary adjustment model)[§]	7.7 (2.6–22.9)	<.001
Mobility[§]	2.1 (1.5–2.8)	<.001
Vision[§]	1.5 (0.4–6.1)	.54
Hearing[§]	1.2 (0.4–3.6)	.66
Nutrition[§]	3.9 (1.4–1.4)	.008
Comorbidity[§]	5.8 (0.7–44.4)	.09
Cognition[§]	8.9 (2.8–28.4)	<.001
History of delirium[§]	5.8 (2.2–15.0)	<.001
Psychosocial[§]	1.7 (1.3–2.2)	<.001
Physical fitness[§]	1.9 (0.7–4.7)	.19

Temporary need for a care facility was considered discharge to a care facility. GFI = Groningen frailty indicator.
[†] Outcome adjusted for sex, body mass index, and smoking status.
[§] Outcome adjusted for sex, body mass index, smoking status, Charlson Comorbidity Index, and type of intervention.

Informing patients about their specific risks at the time of counselling is an important step towards personalising their expectations on post-operative recovery.

In the cohort, 29.2% of patients were considered frail, mostly due to problems in the domains of comorbidity and physical fitness. The prevalence of frailty in the literature varies widely, with rates exceeding 50%.[15] But because many different instruments are used to measure frailty, it is difficult to reliably compare those results. Most of these instruments involve the definition of physical frailty by Fried et al.[33] Comparing the tools with each other and implementing clinical use is therefore difficult, especially since some domains of frailty have a more powerful effect on outcome than others. When choosing a particular frailty tool (especially in single domain tools), in a sense it is not frailty that is determined but a variation or an approximation of the syndrome.

In this study, frailty was an independent risk factor for higher complication rates, with 32.6% of patients having one or more complications during hospital admission. These numbers correspond well with the literature.[12,15,34] Interestingly, after analysis of the individual domains, problems in the domain of cognition proved an important risk factor for post-operative morbidity, a relationship previously detected in a cohort of geriatric patients.[35,36] Although cognitive impairment is difficult to optimise pre-operatively, several patient specific interventions should be taken into account. In any case, there should be a critical analysis with regard to the use of medication, specifically anticholinergics.[37] Also specific additional laboratory tests could screen for possible diseases influencing the cognitive status, such as thyroid dysfunction.[38]

Preventive nursing interventions, including early mobilisation, oral, and nutritional assistance and orienting communication can be implemented. Three large meta-analysis are currently being performed on the effect of prehabilitation, exercise, and nutrition on surgical outcomes, i.e post-operative complications and hospital length of stay.[39–43] Also, optimisation of the anaesthetic techniques should be considered, since anaesthetic technique and pain control have a great impact on outcome after surgery among frail patients.[44–46]

Age was found to be a negative effect modifier, implying that the effect of frailty is lower with advanced age. Frailty is a state of increased vulnerability due to physiological changes in the brain, endocrine system, immune system, and the muscles.[33] As a result, relatively ‘minor’ illnesses may have greater impact on the frail population. All these systems are to a great extent related to age.

The 30 day mortality rate was 2.3%, which is at the low end of the spectrum.[34] Frailty had a significant influence on mortality, also after adjusting for all confounders, comparable with previous findings.[12,15]

The readmission rate for the total cohort was 5.9%, which is substantially lower than another recent publication in vascular surgery patients.[47] Although several studies have focused on frailty and post-operative morbidity and mortality, their effects on readmission have been underexposed or show conflicting results.[34,47,48] In this study the presence of frailty did not lead to a difference in readmission rate. Although readmission is sometimes inevitable for medical reasons, the transition back home could be eased if enhanced recovery programmes or patient specific follow up programmes were initiated.

There was a strong relationship between frailty and discharge to a care facility. The inability to return home leads to a huge amount of stress and consequently a decrease in quality of life, as well as a significant rise in costs.[49] Adjustments to type of care and daily routine could be implemented in electively treated, high risk patients. Preparing a good post-discharge plan together with the general practitioner, in terms of more home care or a greater role for caregivers could help patients return to their own environment.

This study has a few limitations that need to be addressed. First, the GFI was used to measure frailty compared with many other available tools used in geriatric assessment programmes because it is a short and simple questionnaire. Second, despite the prospective nature of the study some items of the GFI were missing. Since frailty is not a static condition but subject to influences over time and changes in medical condition, determining those missing items afterwards will result in a different outcome.[50] The most common item missing concerned the history of delirium, since the first version of the GFI made no distinction between current problems with memory and history of delirium. Factors with a more important influence on outcome (mobility, cognition, and psychosocial condition) however had significantly fewer missing items. To correct for those missing items, multiple imputations were made. Although this is a statistically validated method leading to reliable outcomes, theoretically this could have led to an underestimation of the effect. Third, the rate of major limb amputation was significantly higher in the frail group than in the non-frail group. This could have led to a misinterpretation of the results. However, after adjusting for type of intervention (including amputation) this effect was no longer significant. Fourth, in this study patients undergoing only a percutaneous intervention were excluded, since complications after those interventions are mostly the result of progression of disease. Last, the results of this study may have consequences on shared decision making when dealing with elderly patients with impaired cognition since they might not understand the increased risks of undergoing an elective vascular procedure. In this study only the outcomes after the procedure were considered and policies have not yet been adjusted accordingly. However, these results will be taken into account in future decision making.

Frailty is one of the great challenges for healthcare in the 21st century. Surgical techniques improve constantly, but optimisation of pre-operative status might have an equally significant influence on post-surgical outcome. This study shows that frailty is a multifactorial syndrome that leads to a higher risk of post-operative complications and discharge to a nursing home. Limitations in mobility, cognition, and psychosocial condition appear to have a more pronounced impact on outcome and to a large extent determine the presence and degree of frailty. Although frailty should not be a reason to refrain from treatment, it is important to identify patients at risk and provide appropriate care. The most recent guidelines of the ESVS also focus on pre-operative risk assessment and have identified specific risk factors for impaired outcome after specific interventions.[51–55] Although they did not use the GFI to measure frailty, they also indicate i.e cardiac and pulmonary disease, but also nutritional status as risk factors for post-operative complications. We feel that, although the ESVS guideline should be followed, the GFI is a simple and quick tool that can also be very helpful in defining frailty and to estimate the risk for other postoperative complications and discharge to a care facility. Reversible components provide an opportunity for customised preoperative care.

CONFLICT OF INTEREST

None.

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None.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2019.04.031.

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