G Model
AGG-3123; No. of Pages 7

ARTICLE IN PRESS

Archives of Gerontology and Geriatrics xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Factors influencing the progress of mobilization in hip fracture patients during the early postsurgical period?—A prospective observational study

Benjamin Buecking [a,*], Katharina Bohl [b], Daphne Eschbach [a], Christopher Bliemel [a], Rene Aigner [a], Monika Balzer-Geldsetzer [b], Richard Dodel [b], Steffen Ruchholtz [a], Florian Debus [a]

[a] Department of Trauma, Hand and Reconstructive Surgery, Philipps-University of Marburg, Marburg, Germany
[b] Department of Neurology, Philipps-University of Marburg, Marburg, Germany

ARTICLE INFO

Article history:
Received 26 June 2014
Received in revised form 16 January 2015
Accepted 26 January 2015
Available online xxx

Keywords:
Hip fracture
Fragility fracture
Geriatric fracture
Mobilization
Rehabilitation

ABSTRACT

Objective: The aim of the present study was to determine the independent factors influencing mobilization progress after geriatric hip fractures.
Patients and Methods: 392 Hip fracture patients older than 60 years were included in this prospective, observational, cohort study. The progress of mobilization was measured with walking ability 4 days post-surgery, ability to climb stairs until discharge and the Tinetti test at discharge. Factors correlated with the progress of mobilization were determined using multivariate analyses.
Results: The independent factors influencing *walking ability 4 days post-surgery* were the pre-fracture Charlson Comorbidity Index (OR = 0.834, $p = 0.005$), the American Society of Anesthesiologists Score (OR = 0.550, $p = 0.013$), pre-fracture Barthel Index ([BI], OR = 1.019, $p = 0.012$) and risk for depression, as measured by the Geriatric Depression Scale, (OR = 0.896, $p = 0.013$). The probability of *climbing stairs* until discharge was influenced by the patient's age (OR = 0.840, $p < 0.001$), pre-fracture BI (OR = 1.047, $p = 0.042$), cognitive impairment, as measured by the mini mental state examination (OR = 1.182 $p = 0.008$), pre surgical hemoglobin (OR = 1.026, $p = 0.044$), time until surgery (OR = 0.961, $p = 0.023$), duration of surgery (OR = 0.982, $p = 0.014$), and surgery type (prosthesis, OR = 4.545, $p = 0.001$). Similar variables influenced the *Tinetti test* ad discharge.
Conclusion: While pre-fracture co-morbidities and function cannot be changed, the treatment of patients with cognitive impairment and depressive symptoms should be optimized. Efforts should be undertaken to ensure early surgery for all hip fractures.

1. Introduction

Hip fractures are common in aging societies with an age-standardized incidence of more than 150/100,000 per year in developed countries (Kanis et al., 2012). The total number of these fractures is expected to increase considerably because of the demographic changes expected over the coming decades. Hip fractures are associated with functional decline, high morbidity rates, and premature death (Marks, 2010; Leibson, Tosteson, Gabriel, Ransom, & Melton, 2002). Therefore, hip fractures and their consequences have been identified as one of the most serious healthcare problems affecting the elderly (Marks, 2010; Brauer, Coca-Perraillon, Cutler, & Rosen, 2009).

An important goal after hip fracture surgery is to achieve functional recovery with walking independence to help patients avoid institutionalization. Walking ability seems to be an early predictor of functional outcomes after femoral neck fractures (Laflamme, Rouleau, Leduc, Roy, & Beaumont, 2012). In a recent study, Bellelli et al. (2012) created a model that included the factors that have been shown to reduce the probability of walking independence at discharge from rehabilitation. These factors were cognitive impairment, limited function and activities of daily living, male sex, increased age, elevated or depressed body mass index (BMI), a greater number of drugs taken upon admission, and joint replacement for hip fracture repair compared to internal fixation.

Although it has been assumed that early mobilization is of great importance for the long-term function of these vulnerable patients,

* Corresponding author. Tel.: +49 6421 58 66216; fax: +49 6421 58 66721.
E-mail address: buecking@med.uni-marburg.de (B. Buecking).

http://dx.doi.org/10.1016/j.archger.2015.01.017
0167-4943/

valid data regarding the factors influencing function and walking ability, particularly immediately after hip fracture surgery, are sparse.

To identify the independent factors influencing the course of mobilization, in this study, we prospectively observed the mobilization progress of hip fracture patients during the postsurgical period until discharge from acute care hospital.

2. Methods

At our acute care trauma department of the university hospital Marburg, we performed a prospective, observational, cohort study that included 402 patients older than 60 years with proximal femoral fractures (ICD-10 S72.0-72.2 [ICD-10]) (Buecking et al., 2013). The exclusion criteria for this study were polytrauma (ISS $\geq$ 16) and malignancy-related fractures. The recruitment period ranged from April 1, 2009 to September 30, 2011.

For the present analysis, we used data from a subgroup of 392 patients. A total of 10 patients were excluded because patients' caregivers on admission indicated patients' inability to walk prior to the fracture.

All patients were examined by trained study staff (medical doctors or research study assistents), and the following patient characteristics were collected on admission: the socio-demographic data (e.g., age and sex), type of fracture; American Society of Anesthesiologists (ASA) score (Anesthesiologists ASo, 2010); and Charlson Comorbidity Index (CCI) (Charlson, Pompei, Ales, & MacKenzie, 1987).

2.1. Clinical data

During hospitalization the following data were documented: the interval between the hospital admission and surgery, surgery type (i.e., prosthesis or internal fixation), hemoglobin levels prior to the fracture, and surgery duration. The duration of inpatient treatment in our department, serious complications (grade IV complications according to Dindo's classification (Dindo, Demartines, & Clavien, 2004)) and in-hospital mortality were also documented.

2.2. Questionnaires

The following questionnaires were assessed on admission. The pre-fracture activity level was assessed by the Barthel Index (BI), according to the Hamburg Classification Manual (Lübke, Meinck, & Von Renteln-Kruse, 2004). This questionnaire contents 10 items with value from 0 to 15: Presence of absence of fecal incontinence, presence or absence of urinary incontinence, help needed with grooming, toilet use, feeding, transfers, walking, dressing, climbing stairs and bathing. These items reflect important activities of daily living. The full BI results in 0 (lowest activity level) to 100 points (highest activity level).

Pre-fracture Depression was evaluated using the 15-item short form of the Geriatric Depression Scale (GDS), with a value from 0 (not depressed) to 15 (highly depressed) (Sheikh and Yesavage, 1986). Patients have to answer general questions like "Are you basically satisfied with your life?" or "Do you feel you're your situation is hopeless?" either "yes" or "no". Patients with a GDS $>$ 4 suggest the presence of depressive symptoms to achieve high sensitivity in the depression screening (Almeida & Almeida, 1999).

Cognitive ability was assessed by the mini-mental status examination (MMSE) (Folstein, Folstein, & McHugh, 1975). The MMSE is a reliable 30-point screening test which contains questions in eight different categories. These categories are orientation (time and place), registration, attention and calculation, recall, language, repetition and complex commands. The questionnaire results in a score from 0 to 30 points. Based on the German guideline for dementia the MMSE could – in combination with further tests of dementia – be divided in 4 groups: no cognitive impairment (27–30), mild cognitive impairment (20–26), and moderate dementia (10–19) und severe dementia (0–9) (AWMF, 2012).

2.3. Surgical treatment

We treated all hip fractures with surgery, either internal fixation or hip arthroplasty. The patients with displaced femoral neck fractures were treated with either bipolar hemiarthroplasty or total hip arthroplasty (THA), whereas the patients with non-displaced femoral neck fractures or stable trochanteric fractures were treated with dynamic hip screws. Intramedullary nails were used for internal fixation of unstable (sub-) trochanteric fractures.

2.4. Hip fracture rehabilitation protocol

Hip fracture patients were mobilized by our physical therapists. Additionally our nurses provided assistance during mobilization (e.g., for visits of the toilet). Mobilization was performed daily from the first postsurgical day, except on Sundays. The physiotherapist spent 30 min with the patients 2 times per day. Full weight bearing on the fractured hip was allowed immediately post-surgery. The range of motion was not restricted except for patients that had received THA (flexion max. 90°, internal rotation max. 0°). Various aids, such as canes, crutches, wheeled walkers, gait trainers, were used for mobilization (Buecking, Wack, Oberkircher, Ruchholtz, & Eschbach, 2012).

2.5. Level of mobilization

We defined 3 different mobilization levels:

1. *The ability to stand*: This was defined as standing beside the bed without help. The physiotherapist provided help while rising up if necessary.
2. *Walking ability*: This was defined as walking independently with different aids on the ward.
3. *Climbing stairs*: This was defined as the ability to walk stairs with the help of crutches. For safety reasons this was supervised by a physiotherapist.

Each day, the physiotherapist measured and documented whether the different mobilization levels were achieved. For the data analysis, we categorized whether the patients were able to stand 2 days post-surgery, were able to walk on the fourth day post-surgery, and were able to climb the stairs until the day before discharge.

Additionally, we measured patient mobility at discharge according to the Tinetti test (Tinetti, 1986). The Tinetti test is a clinical test for assessing static and dynamic balance abilities of a patient. It includes two parts of clinical examination, the balance test and the gait test. In total patients can reach a score up to 28 points. Patients with a score $\geq$24 had a low risk of falls, whereas a score from 19 to 23 shows a moderate risk of falls and patients with a Tinetti score $\leq$18 points had a high risk of falling.

Institutional review board approval was obtained from the ethics committee of the University of Marburg (AZ 175/08). All patients or their legal representatives provided written informed consent for study participation.

2.6. Statistics

The data were collected in a Filemaker® database (FileMaker Inc., Santa Clara, CA, USA). Double entry with a plausibility check was performed to monitor for data quality.

Please cite this article in press as: Buecking, B., et al., Factors influencing the progress of mobilization in hip fracture patients during the early postsurgical period?—A prospective observational study. Arch. Gerontol. Geriatr. (2015), http://dx.doi.org/10.1016/j.archger.2015.01.017

IBM SPSS statistics 22 (Statistical Package for the Social Science, IBM Cooperation, Armonk, NY, USA) was used for the explorative data analysis. The data are presented as the means and 95% confidence intervals (Cis). Frequencies are provided for the dichotomous variables.

In the bivariate analysis of mobilization progress, we compared the patients who were able to stand 2 days post-surgery, able to walk 4 days after surgery, and able to climb stairs until discharge to the patients who did not reach the corresponding levels of mobilization. The Kolmogorov–Smirnov test showed a normal distribution. Therefore, Student's *t*-test was used to evaluate the differences in the continuous variables. Dichotomous variables were analyzed with Fisher's exact test. For the bivariate analysis of the Tinetti test at discharge, we calculated Spearmen's correlation coefficients for the numeric and dichotomous variables. Multiple logistic regression analyses were used to identify the variables able to differentiate between the patients who showed progress in mobilization and the patients who did not. A multiple linear regression analysis was used to identify the independent determinants of the Tinetti test at discharge. We chose backward selection for all regression analyses. The variables used in the multiple regression analysis were specified based on data from previous studies. Variables were screened with Spearman's rank correlation. All assumptions regarding the multivariate analysis, including homoscedasticity, linearity, autocorrelation, normally distributed errors, and multicollinearity, were investigated using the appropriate methods. The fraction of variability explained was calculated for each regression model based on the R^2 (coefficient of determination) method, as appropriate.

3. Results

The baseline characteristics and data for treatment of the 392 hip fracture patients are described in Table 1. The mean hospitalization duration was 14 d (95% CI, 13–14 d). We recorded 20 (5%) severe complications. These were myocardial infarction ($n = 9$), ischemic stroke ($n = 3$), acute renal failure ($n = 3$), respiratory failure ($n = 2$), acute heart failure ($n = 1$), epileptic seizure ($n = 1$) and perforated sigmoid diverticulitis ($n = 1$). In-hospital mortality was 6% ($n = 25$; 95% CI, 4.1–8.7%).

In the bivariate analyses, we found 6 baseline parameters that were significantly associated with a lower likelihood of patients being able to stand 2 days post-surgery: (1) a higher ASA score, (2) a lower BI, (3) a higher CCI, (4) lower cognitive status (MMSE), (5) a higher score on the GDS, and (6) delay of surgery (Table 1). For walking abilities 4 days post-surgery, we found the same influencing parameters. In addition, older patients, men and patients with lower pre-surgical hemoglobin levels were less likely to be able to walk whereas delay of surgery has no influence on walking ability (Table 2). Similar variables influenced the probability of climbing stairs during hospitalization; additionally in contrast to the previous levels of mobilization (sub-)trochanteric fractures and internal fixation were associated with a lower probability of walking stairs compared to femoral neck fractures and joint replacement, but sex was not an influencing factor (Table 2).

Several parameters were significantly correlated with the Tinetti test at discharge (mean 10, SD 8, 95% CI 9–10), including the patient's age, fracture location, ASA score, pre-fracture BI, pre-fracture CCI, MMSE on admission, GDS, pre-surgical hemoglobin level and the surgery type (Table 3). The strongest correlations were found for the pre-fracture BI ($r = 0.557$) and the MMSE ($r = 0.514$).

The multiple regression analysis for probability of *standing* did not reach an acceptable reliability (adjusted $R^2 = 0.024$). Only the MMSE (OR = 1.041, $p = 0.022$) was associated with the probability of *standing*.

Table 1
Patients' characteristics and data for treatment.

		All patients($n = 392$)
Age	Mean	81 (SD 8)
	95% CI	80–82
Gender	Male	108 (28%)
	Female	284 (72%)
Fracture location	Femoral neck	190 (49%)
	Trochanteric	181 (46%)
	Subtrochanteric	21 (5%)
ASA score	Mean	2.9 (SD 0.6)
	95% CI	2.8–3.0
Pre-fracture Barthel Index	Mean	81 (SD 23)
	95% CI	78–83
Charlson Comorbidity Index	Mean	2.4 (SD 2.3)
	95% CI	2.1–2.6
MMSE-score	Mean	21 (SD 9)
	95% CI	20–22
Pre-fracture GDS	Mean	3.7 (SD 3.0)
	95% CI	3.4–4.0
Pre-surgical hemoglobin (g/l)	Mean	125.6 (SD 17.0)
	95% CI	123.9–127.2
Time until surgery (h)	Mean	18 (SD 13)
	95% CI	17–20
Duration of surgery (min)	Mean	61 (SD 30)
	95% CI	58–64
Type of surgery	Internal fixation	231 (59%)
	Prosthesis	161 (41%)

g/l = gram/liters, h = hours, min = minutes.

The independent factors influencing *walking ability 4 days post-surgery* were the ASA score (OR = 0.550, $p = 0.013$), pre-fracture BI (OR = 1.019, $p = 0.012$), pre-fracture CCI (OR = 0.834, $p = 0.005$) and the GDS (OR = 0.896, $p = 0.013$, adjusted $R^2 = 0.229$, Table 4).

The probability of *climbing stairs* until discharge (adjusted $R^2 = 0.517$) was influenced by age (OR = 0.840, $p < 0.001$), pre-fracture BI (OR = 1.047, $p = 0.042$), MMSE (OR = 1.182, $p = 0.008$), pre-surgical hemoglobin (OR = 1.026, $p = 0.044$), time until surgery (OR = 0.961, $p = 0.023$), surgery duration (OR = 0.982, $p = 0.014$), and surgery type (prosthesis, OR = 4.545, $p = 0.001$) (Table 5).

We found similar variables influencing the *Tinetti test* at discharge (adjusted $R^2 = 0.356$). The main influencing factors were pre-fracture BI ($ß = 0.268$, $p < 0.001$), the MMSE ($ß = -0.174$, $p = 0.003$), age ($ß = -0.170$, $p = 0.002$) and type of surgery (prosthesis, $ß = 0.158$, $p < 0.001$) (Table 6).

4. Discussion

In this prospective, observational study, we aimed to find the factors influencing the progress of mobilization during the early postsurgical period after hip fracture repair. Co-morbidities, limited function prior to fracture and depressive symptoms were the main independent factors associated with poorer walking

Table 2
Patients' characteristics, data for treatment and levels of mobilization.

		Stand after 2 days		*p*	Walk after 4 days		*p*	Walk on stairs		*p*
		Possible (*n* = 222)	Impossible (*n* = 170)		Possible (*n* = 170)	Impossible (*n* = 222)		Possible (*n* = 68)	Impossible (*n* = 324)	
Age	Mean	81 (SD 8)	82 (SD 8)	*0.094*	80 (SD 8)	82 (SD 8)	*0.035*	75 (SD 7)	83 (SD 8)	*<0.001*
	95% CI	80–82	81–83		79–81	82–83		73–77	82–83	
Gender	Male	54 (50%)	54 (50%)	*0.111*	37 (34%)	71 (66%)	*0.030*	15 (14%)	93 (86%)	*0.298*
	Female	168 (59%)	116 (41%)		133 (47%)	151 (53%)		53 (19%)	231 (81%)	
Fracture location	Femoral neck	102 (54%)	88 (46%)	*0.508*	84 (44%)	106 (56%)	*0.840*	45 (24%)	145 (76%)	*0.002*
	Trochanteric	108 (60%)	73 (40%)		76 (42%)	105 (58%)		23 (13%)	158 (87%)	
	Subtr.	12 (57%)	9 (43%)		10 (48%)	11 (52%)		0 (0%)	21 (100%)	
ASA score	Mean	2.8 (SD 0.6)	3.0 (SD 0.6)	*0.002*	2.7 (SD 0.6)	3.0 (SD 0.6)	*<0.001*	2.6 (SD 0.6)	3.0 (SD 0.6)	*0.004*
	95% CI	2.7–2.9	2.9–3.1		2.6–2.8	3.0–3.1		2.5–2.8	2.9–3.0	
Pre-fracture Barthel Index	Mean	83 (SD 22)	77 (SD 25)	*0.006*	89 (SD 19)	74 (SD 24)	*<0.001*	95 (SD 11)	77 (SD 24)	*<0.001*
	95% CI	80–86	73–81		86–92	71–77		92–98	75–80	
Charlson Comorbidity Index	Mean	2.1 (SD 2.2)	2.7 (SD 2.4)	*0.024*	1.6 (SD 1.9)	2.9 (SD 2.5)	*<0.001*	1.5 (SD 2.2	2.5 (SD 2.3)	*0.001*
	95% CI	1.8–2.4	2.3–3.0		1.3–1.9	2.6–3.2		1.0–2.1	2.3–2.8	
MMSE score	Mean	22 (SD 8)	19 (SD 9)	*0.001*	24 (SD 7)	18 (SD 10)	*<0.001*	27 (SD 3.3)	19 (SD 9.2)	*<0.001*
	95% CI	21–23	18–20		23–25	17–20		26–28	18–20	
Pre-fracture GDS	Mean	3.4 (SD 3.0)	4.2 (SD 2.9)	*0.012*	3.0 (SD 2.7)	4.3 (SD 3.1)	*<0.001*	2.6 (SD 2.8)	4.0 (SD 3.0)	*0.001*
	95% CI	2.9–3.8	3.7–4.6		2.6–3.4	3.9–4.8		1.9–3.2	3.6–4.3	
Pre-surgical hemoglobin (g/l)	Mean	126.6 (SD 15.7)	124.1 (SD 18.3)	*0.151*	129.3 (SD 14.9)	122.6 SD (17.7)	*<0.001*	132.7 (SD 15.8)	124.0 (SD 16.7)	*<0.001*
	95% CI	124.5–128.7	121.4–126.9		127.1–131.6	120.2–125.0		128.8–136.5	122.2–125.9	
Time until surgery (h)	Mean	17 (SD 12)	20 (SD 14)	*0.044*	17 (SD 12)	19 (SD 13)	*0.135*	15 (SD 11)	19 (SD 13)	*0.046*
	95% CI	15–19	18–22		15–19	17–21		13–18	17–20	
Duration of surgery (min)	Mean	58 (SD 28)	64 (SD 32)	*0.085*	61 (SD 29)	62 (SD 31)	*0.727*	63 (SD 26)	61 (SD 31)	*0.496*
	95% CI	55–63	59–69		56–65	58–66		57–70	57–64	
Type of surgery	Internal fixation	140 (61%)	90 (39%)	*0.062*	98 (43%)	132 (57%)	*0.836*	30 (13%)	200 (87%)	*0.010*
	Prosthesis	82 (51%)	79 (49%)		71 (44%)	90 (56%)		38 (24%)	123 (76%)	

g/l = gram/liters, h = hours, min = minutes.

ability during the first postsurgical days. Apart from these factors, increased age, cognitive impairment, lower hemoglobin levels, delay of surgery and internal fixation were associated with poorer Tinetti scores and a smaller proportion of patients able to climb stairs at discharge compared to joint replacement.

Table 3
Correlation between Tinetti test at discharge and patients' characteristics and data for treatment.

Patients' characteristics and data for treatment	Tinetti test: Spearmen's coefficient	Tinetti test: *p*-Value
Age	−0.272	<0.001
Gender (females)	0.100	0.058
Fracture location (trochanteric vs. femoral neck)	−0.131	0.012
ASA score	−0.263	<0.001
Pre-fracture Barthel Index	0.557	<0.001
Pre-fracture Charlson Comorbidity Index	−0.341	<0.001
MMSE on admission	0.514	<0.001
Pre-fracture Geriatric Depression Scale	−0.290	<0.001
Pre-surgical hemoglobin (g/l)	0.232	<0.001
Time until surgery surgery (h)	−0.051	0.351
Duration of surgery (min)	0.054	0.305
Type of surgery (prosthesis)	0.114	0.030

g/l = gram/liters, h = hours, min = minutes.

One of the most important goals after hip fracture surgery is to achieve functional recovery with walking independence, thereby preventing patients from being institutionalized. Given that walking ability is an early predictor of functional outcomes after femoral neck fractures (Laflamme et al., 2012), it can be assumed that early mobilization is of great importance for the long-term function of these vulnerable patients. Additionally, successful mobilization might prevent patients from complications, such as pressure sores or pneumonia, during the post-surgical period.

Most available studies have focused on factors affecting the functional outcomes of hip fracture patients after rehabilitation (Hershkovitz, Kalandariov, Hermush, Weiss, & Brill, 2007; Morghen et al., 2011a; Lenze et al., 2004; Givens, Sanft, & Marcantonio, 2008) instead of functional and walking abilities, particularly immediately after hip fracture surgery. We found that limited function was the most important factor influencing mobilization success during the postsurgical period (Tables 4 and 5). In accordance with our findings, Hershkovitz et al. (2007) have suggested that patients with limited function prior to fracture had poorer functional outcomes after rehabilitation. With regard to cognitive impairment, our results were comparable to the findings from previous studies regarding patient functioning and walking ability after rehabilitation (Hershkovitz et al., 2007; Morghen et al., 2011a; Lenze et al., 2004; Givens et al., 2008; Lögters et al., 2008;

Table 4
Multiple regression analysis of factors influencing ability for walking 4 days after surgery.

Patients' characteristics	Probability for walking ability 4 days after surgery			
	B	OR	95% CI of OR	*p*-Value
ASA score	−0.598	0.550	0.337; 0.896	0.016
Pre-fracture Barthel Index	0.019	1.019	1.004; 1.034	0.012
Pre-fracture Charlson Comorbidity Index	−0.181	0.834	0.734; 0.948	0.005
Pre-fracture Geriatric Depression Scale	−0.109	0.896	0.822; 0.977	0.013

Note: $R^2 = 0.229$ (Nagelkerkes). Model $\chi^2(6) = 57.040$, $p < 0.001$.

Table 5
Multiple regression analysis of factors influencing ability for walking on stairs until discharge.

Patients' characteristics	Probability for walking stairs until discharge			
	B	OR	95% CI of OR	*p*-Value
Age	−0.175	0.840	0.787; 0.896	<0.001
Pre-fracture Barthel Index	0.046	1.047	1.002; 1.094	0.042
MMSE	0.167	1.182	1.045; 1.335	0.008
Pre-surgical hemoglobin (g/l)	0.025	1.026	1.001; 1.051	0.044
Time until surgery (h)	−0.040	0.961	0.929; 0.994	0.023
Duration of surgery (min)	−0.018	0.982	0.968; 0.996	0.014
Type of surgery (prosthesis)	1.513	4.545	1.855; 11.111	0.001

Note: $R^2 = 0.517$ (Nagelkerkes). Model $\chi^2(3) = 116.406$, $p < 0.001$; g/l = gram/liters, h = hours, min = minutes.

Table 6
Multiple regression analysis of factors influencing Tinetti test at discharge.

Patients' characteristics	Tinetti test			
	β	*B*	95% CI of *B*	*p*-Value
Age	−0.170	−0.178	−0.282 to −0.066	0.002
Pre-fracture Barthel Index	0.268	0.112	0.065–0.163	<0.001
Pre-fracture Charlson score	−0.092	−0.352	−0.794 to −0.039	0.031
MMSE	0.174	0.219	0.070–0.354	0.003
Geriatric depression scale on admission	−0.112	−0.309	−0.570 to −0.021	0.035
Pre surgical hemoglobin (g/l)	0.121	0.059	0.008–0.105	0.023
Time until surgery (h)	−0.104	−0.071	−0.137 to −0.007	0.030
Type of surgery (prosthesis)	0.158	2.760	1.182–4.531	<0.001

Note. adjusted $R^2 = 0.356$; g/l = gram/liters, h = hours.

Hirose et al., 2010). However, our data showed that also cognitive impaired patients (mean MMSE: 24) were able to walk 4 days post-surgery (Table 2). This finding supports the Morghen's hypothesis that walking ability is achievable despite cognitive impairment (Morghen et al., 2011a). This finding underlines the need to adequately identify and manage cognitive impairment. The MMSE and pre-fracture BI were also part of the prognostic model developed by Bellelli et al. (2012) predicting the recovery of walking independence. In contrast to the results of Givens et al. (2008) 1 month after hip fracture, we found that depression was an independent factor influencing postsurgical mobilization. Morghen et al. (2011b) showed that only moderate to severe depression was an independent negative predictor of walking ability. In a previous study, depression was an independent factor for poorer outcomes because depressed patients showed lower participation in the rehabilitation process (Lenze et al., 2004). Adequately reorganizing and managing depression might help to ensure successful participation in rehabilitation. According to Mathew, Hsu, and Young (2013) who identified various comorbidities, our data showed poorer walking ability in patients with higher CCIs and ASA scores. However, we summarized the patients' comorbidities and, therefore, could not analyze the distinct comorbidities in detail. In contrast to Arinzon, Shabat, Peisakh, Gepstein, and Berner (2010) who found that female sex was a factor that negatively impacted the patients' functioning after rehabilitation, we found better walking ability in women compared to men in a bivariate analysis (Table 2). In the multivariate analysis, however, sex was not an independent factor influencing walking ability. Our data also showed a trend toward better Tinetti test results in women compared to men. Our findings were consistent with the literature showing poorer results for men after hip fractures, with increased rates of complications, losing previous independence, and also of premature death (Holt, Smith, Duncan, Hutchison, & Gregori, 2008; Sterling, 2011).

The optimal timing for surgery remains controversial. Studies have reported evidence of a link between surgery delay and increased in-hospital mortality (Uzoigwe et al., 2013; Moja et al., 2012). However, some medical causes or a lack of surgical capacity might also contribute to surgical delay. We found that delaying surgery was – when adjusted for several co-factors – associated with a less frequent ability to climb stairs and poorer function at discharge (Tables 5 and 6). Maybe we did not identify all relevant co-factors, which are responsible for poor mobilization rates. Another reason could be that delay of surgery itself contributed to poorer outcomes due to prolonged perioperative immobilization. Our data supported the beneficial effects of earlier surgery in decreasing not only fatality rates but also in increasing mobility in early-treated patients.

Haentjens et al. (2007) found better functional results at discharge from acute care and lower mortality rates in patients with femoral neck fractures compared to intertrochanteric fractures. In agreement, in the bivariate analysis, we demonstrated that more patients with femoral neck fractures were able to climb stairs compared to patients with trochanteric and subtrochanteric fractures (Table 1). Additionally, we found a positive correlation between femoral neck fractures and Tinetti scores at discharge. However, fracture location was not an independent influencing factor in the multivariate analysis. In contrast to Bellelli et al. (2012) who found that joint replacement was associated with a higher risk of unsuccessful recovery of pre-fracture walking ability, our results suggested that a prosthesis implantation was associated with better mobilization at the end of acute care, compared to patients who received internal fixation (Tables 5 and 6). Consistently, in our patient sample, internal fixation was also associated with poorer quality of life at the end of acute care (Buecking et al., 2013). From our results, it is not possible to conclude that all hip fractures should be treated with joint replacement. There are some types of proximal femoral fractures for which the choice of surgical strategy is unambiguous; displaced femoral neck fractures should be treated with joint replacement instead of internal fixation, (Frihagen, Nordsletten, & Madsen, 2007) while for subtrochanteric fractures, internal fixation with an intramedullary nail is recommended (Micic et al., 2010). Non-displaced femoral neck fractures and trochanteric fractures are usually treated with internal fixation. However, some data indicate higher re-operation rates for non-displaced femoral neck fractures treated with internal fixation compared to joint replacement in displaced femoral neck fractures (Gjertsen, Fevang, Matre, Vinje, & Engesæter, 2011). Additionally, there has been insufficient evidence concerning the optimal treatment of extracapsular hip fractures (Parker & Handoll, 2006). In our opinion, randomized trials are necessary to demonstrate whether patients with the abovementioned fracture types might benefit from joint replacement. Regardless of this question, stable surgical fixation of hip fractures with permission for full weight bearing should be obtained; particularly after internal fixation, efforts should be undertaken to achieve early mobilization.

5. Study limitations

Our study had several limitations. First, of 402 patients, we had to exclude *a priori 10* patients who were unable to walk prior to fracture. Second, we had only a limited number of patients in the subgroup with subtrochanteric fractures, which might have caused bias in the multivariate analyses. Third, we assessed pre-fracture walking ability and BI retrospectively. In our opinion, this method was acceptable for assessing patients' pre-fracture function because it was used in some previous studies (Laflamme et al., 2012; Bellelli et al., 2012). Fourth, our different multivariate models could explain only part of the variance; for example, our model related to walking on stairs obtained an acceptable value of $R^2 = 0.517$, while our model for staying ability was nearly valueless ($R^2 = 0.024$), although many variables were integrated into our regression analysis.

6. Conclusion

In summary, we found that increased age, co-morbidities, limited function prior to fracture, cognitive impairment, depressive symptoms, lower hemoglobin levels, delayed surgery, and internal fixation compared to joint replacement were the main independent factors associated with poorer mobilization in the postsurgical period in geriatric hip fracture patients. Particularly, the treatment of patients at risk for failure of ambulation should focus on mobilization. In addition, the treatment of patients with cognitive impairment and depressive symptoms should be optimized. Although further studies regarding the optimal strategies for distinct hip fracture types, such as non-displaced hip fractures, are necessary, efforts should be undertaken to ensure early surgery for all hip fractures. Joint replacement should be considered instead of internal fixation when the optimal hip fracture repair is unclear. Further evaluations of the long-term outcome are necessary to estimate the predictive value of these prematurely results.

Conflict of interest statement

Each author certifies that he or she and members, or a member of his/her/their immediate family, haves no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the content of the submitted article.

Acknowledgements

The authors would like to thank Anne Hemesath, Kristin Horstmann, Natalie Schubert, Anna Waldermann and Lutz Waschnick who gave contributions to acquisition of data.

References

Almeida, O. P., & Almeida, S. A. (1999). Short versions of the geriatric depression scale: a study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. *International Journal of Geriatric Psychiatry, 14*(10), 858–865.

Anesthesiologists ASo (2010). *ASA physical status classification system*. Anesthesiologists ASo. Available at: 〈http://www.asahq.org/clinical/physicalstatus.htm〉 (Accessed May 2, 2012).

Arinzon, Z., Shabat, S., Peisakh, A., Gepstein, R., & Berner, Y. N. (2010). Gender differences influence the outcome of geriatric rehabilitation following hip fracture. *Archives of Gerontology and Geriatrics, 50*(1), 86–91.

Arbeitsgemeinschaft WissenschaftlichMedizinischer Fachgesellschaften (AWMF) (2012). *S3-guideline, dementia*. AWMF 〈http://www.awmf.de〉 (Accessed 10 July 2012) (long version).

Bellelli, G., Noale, M., Guerini, F., Turco, R., Maggi, S., Crepaldi, G., et al. (2012). A prognostic model predicting recovery of walking independence of elderly patients after hip-fracture surgery. An experiment in a rehabilitation unit in Northern Italy. *Osteoporosis International, 23*(8), 2189–2200.

Brauer, C. A., Coca-Perraillon, M., Cutler, D. M., & Rosen, A. B. (2009). Incidence and mortality of hip fractures in the United States. *JAMA, 302*(14), 1573–1579.

Buecking, B., Wack, C., Oberkircher, L., Ruchholtz, S., & Eschbach, D. (2012). Do concomitant fractures with hip fractures influence complication rate and functional outcome? *Clinical Orthopaedics and Related Research, 470*(12), 3596–3606.

Buecking, B., Struewer, J., Waldermann, A., Horstmann, K., Schubert, N., Balzer-Geldsetzer, M., et al. (2013). What determines health-related quality of life in hip fracture patients at the end of acute care?—A prospective observational study. *Osteoporosis International, 25*(2), 475–484.

Charlson, M. E., Pompei, P., Ales, K. L., & MacKenzie, C. R. (1987). A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *Journal of Clinical Epidemiology, 40*(5), 373–383.

Dindo, D., Demartines, N., & Clavien, P. A. (2004). Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Annals of Surgery, 240*(2), 205–213.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189–198.

Frihagen, F., Nordsletten, L., & Madsen, J. E. (2007). Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: Randomised controlled trial. *BMJ, 335*(7632), 1251–1254.

Givens, J. L., Sanft, T. B., & Marcantonio, E. R. (2008). Functional recovery after hip fracture: The combined effects of depressive symptoms, cognitive impairment, and delirium. *Journal of the American Geriatrics Society, 56*(6), 1075–1079.

Gjertsen, J. E., Fevang, J. M., Matre, K., Vinje, T., & Engesæter, L. B. (2011). Clinical outcome after undisplaced femoral neck fractures. *Acta Orthopaedica, 82*(3), 268–274.

Haentjens, P., Autier, P., Barette, M., Venken, K., Vanderschueren, D., Boonen, S., et al. (2007). Survival and functional outcome according to hip fracture type: A one-year prospective cohort study in elderly women with an intertrochanteric or femoral neck fracture. *Bone, 41*(6), 958–964.

Hershkovitz, A., Kalandariov, Z., Hermush, V., Weiss, R., & Brill, S. (2007). Factors affecting short-term rehabilitation outcomes of disabled elderly patients with proximal hip fracture. *Archives of Physical Medicine and Rehabilitation, 88*(7), 916–921.

Hirose, J., Ide, J., Yakushiji, T., Abe, Y., Nishida, K., Maeda, S., et al. (2010). Prediction of postoperative ambulatory status 1 year after hip fracture surgery. *Archives of Physical Medicine and Rehabilitation, 91*(1), 67–72.

Holt, G., Smith, R., Duncan, K., Hutchison, J. D., & Gregori, A. (2008). Gender differences in epidemiology and outcome after hip fracture: Evidence from the Scottish Hip Fracture Audit. *The Journal of Bone and Joint Surgery. British Volume, 90*(4), 480–483.

Kanis, J. A., Odén, A., McCloskey, E. V., Johansson, H., Wahl, D. A., Cooper, C., et al. (2012). A systematic review of hip fracture incidence and probability of fracture worldwide. *Osteoporosis International, 23*(9), 2239–2256.

Laflamme, G. Y., Rouleau, D. M., Leduc, S., Roy, L., & Beaumont, E. (2012). The Timed Up and Go test is an early predictor of functional outcome after hemiarthroplasty for femoral neck fracture. *The Journal of Bone and Joint Surgery. American Volume, 94*(13), 1175–1179.

Leibson, C. L., Tosteson, A. N., Gabriel, S. E., Ransom, J. E., & Melton, L. J. (2002). Mortality, disability, and nursing home use for persons with and without hip fracture: A population-based study. *Journal of the American Geriatrics Society, 50*(10), 1644–1650.

Lenze, E. J., Munin, M. C., Dew, M. A., Rogers, J. C., Seligman, K., Mulsant, B. H., et al. (2004). Adverse effects of depression and cognitive impairment on rehabilitation participation and recovery from hip fracture. *International Journal of Geriatric Psychiatry, 19*(5), 472–478.

Lögters, T., Hakimi, M., Linhart, W., Kaiser, T., Briem, D., Rueger, J., et al. (2008). Early interdisciplinary geriatric rehabilitation after hip fracture: Effective concept or just transfer of costs? *Unfallchirurg, 111*(9), 719–726.

Lübke, N., Meinck, M., & Von Renteln-Kruse, W. (2004). The Barthel Index in geriatrics. A context analysis for the Hamburg Classification Manual. *Zeitschrift für Gerontologie und Geriatrie, 37*(4), 316–326.

Marks, R. (2010). Hip fracture epidemiological trends, outcomes, and risk factors, 1970–2009. *International Journal of General Medicine, 3*, 1–17.

Mathew, R. O., Hsu, W. H., & Young, Y. (2013). Effect of comorbidity on functional recovery after hip fracture in the elderly. *American Journal of Physical Medicine & Rehabilitation, 92*(8), 686–696.

Micic, I. D., Mitkovic, M. B., Park, I. H., Mladenovic, D. B., Stojiljkovic, P. M., Golubovic, Z. B., et al. (2010). Treatment of subtrochanteric femoral fractures using selfdynamisable internal fixator. *Clinics in Orthopedic Surgery, 2*(4), 227–231.

Moja, L., Piatti, A., Pecoraro, V., Ricci, C., Virgili, G., Salanti, G., et al. (2012). Timing matters in hip fracture surgery: Patients operated within 48 hours have better outcomes. A meta-analysis and meta-regression of over 190,000 patients. *PLoS ONE, 7*(10), e46175.

Morghen, S., Gentile, S., Ricci, E., Guerini, F., Bellelli, G., & Trabucchi, M. (2011). Rehabilitation of older adults with hip fracture: Cognitive function and walking abilities. *Journal of the American Geriatrics Society, 59*(8), 1497–1502.

Morghen, S., Bellelli, G., Manuele, S., Guerini, F., Frisoni, G. B., & Trabucchi, M. (2011). Moderate to severe depressive symptoms and rehabilitation outcome in older adults with hip fracture. *International Journal of Geriatric Psychiatry, 26*(11), 1136–1143.

Parker, M. J., & Handoll, H. H. (2006). Replacement arthroplasty versus internal fixation for extracapsular hip fractures in adults. *Cochrane Database of Systematic Reviews*, (2), CD000086.

Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. *Clin Gerontol., 5*(1/2), 165–173.

Sterling, R. S. (2011). Gender and race/ethnicity differences in hip fracture incidence, morbidity, mortality, and function. *Clinical Orthopaedics and Related Research, 469*(7), 1913–1918.

Tinetti, M. E. (1986). Performance-oriented assessment of mobility problems in elderly patients. *Journal of the American Geriatrics Society, 34*(2), 119–126.

Uzoigwe, C. E., Burnand, H. G., Cheesman, C. L., Aghedo, D. O., Faizi, M., & Middleton, R. G. (2013). Early and ultra-early surgery in hip fracture patients improves survival. *Injury, 44*(6), 726–729.

Please cite this article in press as: Buecking, B., et al., Factors influencing the progress of mobilization in hip fracture patients during the early postsurgical period?—A prospective observational study. Arch. Gerontol. Geriatr. (2015), http://dx.doi.org/10.1016/j.archger.2015.01.017