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Article *in* Osteoporosis International · October 2016

DOI: 10.1007/s00198-016-3784-3

Osteoporos Int (2017) 28:667–675
DOI 10.1007/s00198-016-3784-3

ORIGINAL ARTICLE

Early post-surgical cognitive dysfunction is a risk factor for mortality among hip fracture hospitalized older persons

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Received: 13 May 2016 / Accepted: 22 September 2016 / Published online: 7 October 2016

Abstract

Summary This study investigates the relationship between cognitive dysfunction or delirium detected in the early post-surgical phase and the 1-year mortality among 514 hip fracture hospitalized older persons. Patients with early cognitive dysfunction or delirium experienced a 2-fold increased mortality risk. Early post-operative cognitive dysfunction and delirium are negative prognostic factors for mortality.

Background and purpose Premorbid cognitive impairment and dementia in older individuals negatively affect functional recovery after hip fracture. Additionally, post-operative delirium is an established risk factor for negative outcomes among hip fracture patients. While the majority of hip fracture patients experience minor post-surgical cognitive dysfunction, the prognostic value of this phenomenon is unknown. Therefore, we investigated the relationship between minor cognitive dysfunction or delirium detected in the early post-surgical phase and the 1-year mortality after index hip fracture.

Subjects and methods We enrolled 514 patients with hip fracture (77.4 % women), aged 65 years or older (mean age 83.1 ± 7.3 years), who underwent surgical hip fracture repair. Patients were assessed daily from the second to the fourth post-operative day and at 3, 6, and 12 months thereafter. All participants underwent comprehensive assessment, including detection of delirium by using the confusion assessment method and evaluation of cognitive function by using mini-mental state examination (MMSE; score range 0 to 30, with lower scores indicating poorer performance). In the absence of delirium, post-surgical cognitive dysfunction was defined as having low performance on MMSE. Vital status of 1 year after the index fracture and date of death were gathered from local registries.

Results The observed 1-year mortality rate was 14.8 %. Men were more likely to die than women within 1 year of the index fracture ($p < 0.01$). Compared to participants with better cognitive performance, those with MMSE < 24, as well as those with delirium in the post-operative phase, showed a significantly higher 1-year mortality rate (23.3 versus 17.9 and 8.1 %, respectively). Independent of age and sex, post-operative cognitive dysfunction as well as delirium was both associated with a 2-fold increased mortality risk.

Conclusions The presence of minor cognitive dysfunction in the early post-surgical phase is a negative prognostic factor for mortality among elderly hip fracture patients. The burden of minor cognitive dysfunction is likely superimposed on that of delirium in subgroups of frail patients.

Keywords Cognitive function · Hip fracture · Mortality · Delirium

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Introduction

The aging population poses a challenge for healthcare providers worldwide due to the concomitant rise in the incidence of chronic and degenerative diseases. Osteoporosis and fragility fractures are among the most critical health issues as identified by the World Health Organization. In 2000, 1.6 million hip fractures were reported worldwide [1], and epidemiological studies estimate a 12.1 and 4.6 % lifetime risk of hip fracture for women and men, respectively [2]. Each year in Italy, almost 18,000 elderly people become completely disabled as a consequence of hip fractures, resulting in inestimable human suffering and substantial social cost [3]. Approximately, 15–25 % of older individuals who sustain a hip fracture die within one-year of the event, while more than 30 % of survivors lose the mobility function and the ability to live independently [4], with clinical and social consequences including depression, fear of falling, disability, institutionalization, and social isolation [5]. A better understanding on the factors involved in catastrophic sequel after hip fracture, including mortality and suboptimal recovery, are clinical and public health priorities to develop innovative and effective interventions beyond surgery.

Cognitive frailty is the progressive constriction of brain homeostatic reserve causing an inability of older persons to cope with environmental stressors [6]. In the presence of acute stressors like hip fractures and surgical procedures, older patients with underlying cognitive frailty are more likely to develop acute cognitive complications, such as delirium and cognitive impairment [7].

Delirium is a clinical syndrome among hip fracture patients, characterized by acute and fluctuating changes in mental status, reduced environmental awareness, disruption of attention, and potentially negative outcomes including functional decline, dementia, institutionalization, and mortality [8–10]. While not all hip fracture patients develop full-blown delirium, many do experience acute changes in cognitive functioning. These changes are often subtle and manifold, depending on the affected cognitive domains and the degree of change [11], and are commonly overlooked, undiagnosed, and troubling to patients and hospital staff.

To date, the prognostic value of the onset of acute cognitive impairment following hip surgical repair is unknown. Several studies have investigated post-operative cognitive dysfunction among patients undergoing elective surgery by using a comprehensive neuropsychological assessment battery of tests administered upon admission and repeated after surgery [12, 13]. However, the repeated administration of a comprehensive neuropsychological assessment is not practical considering the acute-care setting of hip fracture treatment. In this context, a more practical screening tool investigating general cognition during the early post-operative period should be considered a more suitable option. Using a large multi-center cohort of hospitalized elderly hip fracture patients, we aimed to identify socio-demographic and clinical characteristics related to the presence of cognitive dysfunction and delirium occurring during the early post-operative period. Additionally, our goal was to investigate the relationship between post-surgical cognitive complications and the 1-year mortality risk in this population.

Subjects and methods

Study sample

The CODE (Connections between the outcomes of osteoporotic hip fractures and depression, delirium or dementia in elderly patients) project is an epidemiological study conducted on a representative sample of older individuals hospitalized for a femoral neck fracture in the Tuscany and Umbria regions of central Italy. This study was developed to investigate factors affecting functional recovery of hip fracture patients. The rationale, design, inclusion and exclusion criteria, and data collection have been described elsewhere [14]. The study protocol complies with the Declaration of Helsinki and was approved by the local Ethics Committee.

Briefly, from January 2012 to April 2013, 514 older patients with fragility hip fracture, aged >65 years and admitted to orthopedic and orthogeriatric wards in two University Hospitals in central Italy were enrolled. Baseline evaluation was performed in the early post-operative phase within 4 days of surgery by implementing a comprehensive geriatric assessment. Follow-up evaluations at 3, 6, and 12 months from index fracture were scheduled. A proxy was interviewed when the subject was unable to provide required information.

Demographic, behavioral and health-related characteristics

Demographic data, information on prefracture social context, medical history, and drug treatments were collected from all participants using standardized questionnaires. Cognitive assessment was carried out using the mini-mental state examination [15] (MMSE, corrected for age and education). Affective status was evaluated via the Mini International Neuropsychiatric Interview Plus (MINI-plus) [16] and the 30-item Geriatric Depression Scale [17]. The confusion assessment method (CAM) was applied to identify delirium [18]. In the post-operative phase, participants were defined as affected by "delirium" according to CAM, while as affected by cognitive "dysfunction" when MMSE score was less or equal to 24 points, alternatively they were defined cognitively "intact" with MMSE score higher than 24.

Psychological self-efficacy was identified using the single item Personal Mastery Scale [19]. Furthermore, prefracture functional status was recorded based on the Barthel index

(BI) with a cutoff score of 80 to identify physically independent subjects [20]. Post-surgical recovery was measured using a cumulated ambulation score (CAS) [21], pain was assessed with Visual Analog Scale (VAS), and comorbidity via the Charlson index (CI) [22].

Assessment of delirium and cognitive dysfunction

The diagnosis of delirium was made according to DSM-IV-TR criteria applying the CAM algorithm [23] on a daily basis and the systematic review of nursing staff notes during night shifts. Post-surgical cognitive assessment using MMSE was performed by an expert physician (IP, LB) within 96-h post-surgical intervention. Cognitive dysfunction was defined as a score ≤ 24 on MMSE among patients failing to fulfill criteria for the diagnosis of delirium.

Definition of outcomes

The main outcome was 12-month mortality, defined as death occurring up to a year after surgery. Information regarding deaths was obtained by telephone, structured interview, and by consulting the Regional Registry of Death. Vital status at 1 year after the index fracture and date of death were gathered through the regional registries.

Statistical analysis

The socio-demographic (Table 1) and clinical pre- and post-operative characteristics of the sample were described for the entire sample and by groups defined according to 1-year vital status (Table 2) and cognitive performance (Table 3) as frequency distribution and percentages or mean ± standard deviation, as appropriate according to the nature of variables. The relationship between post-operative cognitive status and 1-year mortality was investigated using cumulative survival analysis and plotted using Kaplan-Meier curves (Fig. 1). After correcting for age and gender, cognitive dysfunction and delirium were analyzed via multinomial logistic regression forcing all the factors significantly affecting the dependent criteria (i.e., mortality) and subsequently tested using Cox proportional hazard regression models (Table 4). All of the analyses were performed using a statistical software package (SPSS 17.0 for Windows, v. 17, SPSS Inc., Chicago, IL, USA).

Results

Baseline characteristics of the entire sample stratified according to 1-year vital status are reported in Table 1. Participants were mainly female (77.4 %), with a mean age of 83.1 ± 7.6. More than half were functionally independent as assessed by BI (61 %) with one out of three living independently at home at the time of fracture (33.8 %). The majority of participants had a CI score lower than 4 (89.5 %) and were prescribed less than 6 drugs daily (75.3 %). The prevalence of dementia and depression were 19.8 and 8.9 %, respectively. Early (within 48 h) access to surgical theater was found in half of the overall sample (56 %). Within the fourth post-operative day, 42 % of participants showed good early functional recovery as assessed by CAS, 37 % were in good pain control (VAS ≤ 3), 70 % had high self-efficacy, and half of patients (50.6 %) expressed cognitive distortions to some extent. Among participants with cognitive problems, 25.9 % were diagnosed with delirium, while 28.2 % experienced minor deficits. Compared to women, men were more likely to die within 1 year of index fracture ($p < 0.01$). The older age groups were more likely to die compared to the youngest ones ($p < 0.001$). As assessed by BI and CI, individuals with poorer functional status and higher comorbidity index were more likely to die ($p < 0.01$). There were no differences in the proportion of survivors and deceased with regard to early surgery, early functional recovery, pain control, depressive symptoms, and personal mastery. Compared to participants with better cognitive performance, those with MMSE ≤ 24 in the post-operative phase showed a significantly higher 1-year mortality rate (20.8 versus 8.7 %). Of note, a lower mortality rate was observed among participants with intact cognitive status (8.1 %) compared to those with post-operative cognitive dysfunction (17.9 %) and with delirium (23.3 %).

Comparisons of survival curves showed significantly higher mortality for patients with post-operative cognitive dysfunction and delirium compared to participants with intact cognitive function [Fig. 1]. Post-operative cognitive status stratification revealed that compared to intact individuals, the prevalence of both dysfunction and delirium tended to be higher in subjects of older age groups ($p < 0.001$), with lower educational level ($p < 0.001$), and with poorer prefracture functional status ($p < 0.001$), while no differences of gender, comorbidity index, and daily drugs intake were found. Subjects that underwent early surgery (within 48 h) were less likely to develop delirium or dysfunction, without however, reaching statistical significance. The majority of subjects with intact post-operative cognitive function tended to show better functional recovery (51.3 %; $p < 0.05$), better pain control (53.9 %; $p < 0.01$), fewer depressive symptoms (51.7 %; $p < 0.01$), and higher self-efficacy (52.6 %; $p < 0.001$). Subjects with cognitive dysfunction and delirium did not show differences in the proportional distribution of these characteristics. After removal of demented individuals from data analysis, Cox logistic multinomial regression with a calculation of proportional hazard ratio was modeled using age and gender as covariates, leading to the finding that cognitive dysfunction and delirium were both associated with a doubled mortality risk (Table 4). Survival analysis was carried out using Kaplan-Meier curves, which revealed no difference in 1-year

Table 1 Demographic characteristics distributed in the overall sample and according to 1-year vital status

Socio-demographic characteristics	Entire sample (*n* 514)	Alive (*n* 438)	Deceased (*n* 76)	*p*	*p**
Gender				<0.01	<0.01
Female	398 (77.4 %)	348 (87.4 %)	50 (12.6 %)		
Male	116 (22.6 %)	90 (77.6 %)	26 (22.4 %)		
Age class, years				<0.001	
65–79	138 (26.8 %)	128 (92.8 %)	10 (7.2 %)		
80–89	277 (53.9 %)	239 (86.3 %)	38 (13.7 %)		
≥90	99 (19.3 %)	71 (71.7 %)	28 (28.3 %)		
Age, years (mean + SD)	83.12 ± 7.26	82.47 ± 7.10	86.83 ± 7.13	<0.001	
Social context				<0.01	<0.01
Living alone	174 (33.8 %)	160 (91.9 %)	14 (8.1 %)		
Living with caregiver	340 (66.2 %)	278 (81.8 %)	62 (18.2 %)		
Education, years				0.26	0.39
≤8	427 (83 %)	364 (85.2 %)	63 (14.8 %)		
>8	87 (16.9 %)	74 (85.1 %)	13 (14.9 %)		
Dementia	102 (19.8 %)	82 (80.4 %)	20 (19.6 %)	0.08	0.09
Depression	46 (8.9 %)	39 (84.7 %)	7 (15.2 %)	0.22	0.4

Variables are expressed as numbers and (percentages). Percentages in the first column refer to the entire sample size. Percentages in the second and the third columns refer to the demographic indicators in the first column. Continuous variables were inspected using *t* test and analysis of variance when testing differences among more than two groups (ANOVA). Age-adjusted statistical significance is also displayed in the last column (*p**). **Key**: education, low: ≤ 8 years; high: > 8 years.

survival estimates between subjects with post-operative cognitive dysfunction and delirium (Fig. 1).

Discussion

This report provides new evidence emphasizing the importance of cognitive complications as predictors of long-term mortality among older individuals. In particular, this is the first study comparing the 1-year mortality risk associated with post-surgical delirium and cognitive dysfunction in a large multicenter cohort of older individuals who underwent acute surgery for hip fracture.

The observed 1-year mortality rate (14.8 %) in the whole cohort is generally consistent with some but not all studies assessing hip fracture patients [24–26]. This discrepancy is likely due to substantial differences in sample sizes and inclusion criteria. In our study, one out of four hip fracture patients experienced delirium and one out of three experienced acute cognitive dysfunction in the early post-operative phase. Individuals with early post-operative delirium and acute cognitive dysfunction were more likely to die compared to those without these conditions.

Furthermore, both delirium and cognitive dysfunction were more prevalent in older and less educated individuals and in those who displayed a worse prefracture functional status. This is consistent with the previous literature indicating that age is the main non-modifiable risk factor for poor cognitive outcomes after surgery [27]. Older patients almost universally hold neurovascular disease risk factors have higher white matter vascular damage burden and possess less cognitive reserve [28], which may place them at a higher risk for cognitive complications after stressful interventions including surgery and anesthesia, as well as hospitalization itself.

In line with other reports [29, 30], comorbidity burden, as assessed by CI, was not found to be higher in subjects with post-operative cognitive dysfunction. In detail, subjects with higher comorbidity index were almost equally distributed in the three cognitive groups, while individuals scoring less than 4 on CI were significantly more prevalent in the cognitively intact group.

The main finding of this study is that the two different cognitive complications investigated were both associated with a two-fold risk of mortality within 1 year. In previous work carried out in different healthcare settings, delirium has been widely studied in association with short and long-term mortality, leading to inconclusive results [10, 31–38]. Therefore, although delirium has consistently been associated with poor outcomes such as prolonged hospital stay, institutionalization, and dementia [32], only few studies have examined the mortality risk associated with delirium in elderly patients after 1 year or more since hip surgery. In this context, one study found an increased mortality risk associated with delirium at 6 months of follow-up and three studies demonstrated an increased risk at 12 months follow-up or more [39–41]. Nightingale et al. assessed patients with hip fracture

Table 2 Pre and post-operative clinical characteristics distributed in the overall sample and according to 1-year vital status

	Entire sample (*n* 514)	Alive (*n* 438)	Deceased (*n* 76)	*p*	*p**
Preoperative characteristics					
Barthel index, (range 0–100)				<0.01	<0.05
≤80	200 (38.9 %)	158 (79 %)	42 (21 %)		
>80	314 (61.1 %)	280 (89.2 %)	34 (10.8 %)		
Charlson index, (range 0–21)				<0.01	<0.01
≥4	54 (10.5 %)	39 (72.2 %)	15 (27.8 %)		
<4	460 (89.5 %)	399 (77.6 %)	61 (13.2 %)		
Polypharmacy				0.23	0.20
<6	127 (24.7 %)	110 (86.7 %)	17 (13.4 %)		
≥6	387 (75.3 %)	328 (84.7 %)	59 (15.3 %)		
Hip surgery timing					
Early (≤48 h)	289 (56.2 %)	250 (86.5 %)	39 (13.5 %)	0.06	0.1
Time to surgery, days, (mean ± SD)	3.1 ± 2.7	3.0 ± 2.2	3.7 ± 4.6	0.351	0.278
Postoperative characteristics					
Cumulated ambulation score (range 0–18)				0.08	0.2
≥6	214 (41.6 %)	188 (87.9 %)	26 (12.1 %)		
<6	229 (44.5 %)	192 (83.8 %)	37 (16.2 %)		
Visual Analogic Scale (range 0–10)				0.35	0.4
>3	323 (62.8 %)	279 (86.4 %)	44 (13.6 %)		
≤3	191 (37.2 %)	159 (83.2 %)	32 (16.8 %)		
MMSE (range 0–30)				<0.001	<0.01
≤24	260 (50.6 %)	206 (79.2 %)	54 (20.8 %)		
>24	254 (49.4 %)	232 (91.3 %)	22 (8.7 %)		
GDS (range 0–30)				0.28	0.15
≥10	226 (44 %)	187 (82.7 %)	39 (17.3 %)		
<10	288 (56 %)	251 (87.2 %)	37 (12.8 %)		
Personal mastery				0.47	0.36
Positive answer	361 (70.2 %)	313 (86.7 %)	48 (13.3 %)		
Negative answer	153 (29.8 %)	125 (81.7 %)	28 (18.3 %)		
Cognitive status				<0.001	<0.01
Intact	236 (45.9 %)	217 (91.9 %)	19 (8.1 %)		
Dysfunction	145 (28.2 %)	119 (82 %)	26 (17.9 %)		
Delirium	133 (25.9 %)	102 (76.7 %)	31 (23.3 %)		

Variables are expressed as numbers and (percentages). Percentages in the first column refer to the entire sample size. Percentages in the second and the third columns refer to the demographic indicators in the first column. Continuous variables were inspected using *t* test and analysis of variance when testing differences among more than two groups (ANOVA). **Key:** *Barthel Index, range 0–100*: high: >80, low: ≤80; *Charslon Index, range 0–21*: high: ≥4, low: <4; *polypharmacy:* present: >6 drugs/daily; *CAS, range 0–18*: high: ≥6; low:<6; *VAS, range 0–10*: high: >3, low:≤3. Cognitive status: intact if MMSE > 24 and no delirium; dysfunction if MMSE ≤ 24 and no delirium; delirium if altered CAM scale at least once during 4 days after surgery, any score at MMSE. Age-adjusted statistical significance is also displayed in the last column (*p**)

between 2 and 5 days after surgery; the adjusted 2-year HR associated with delirium was 2.4 (CI 1.7–3.5) [40]. Edelstein et al. showed that 47/921 (5.1 %) of patients with hip fracture had postoperative delirium and were more likely to have died at 1-year follow-up (unadjusted odds ratio 2.4, CI 1.1–4.9) [41]. Lundstrom et al. found that 72 % femoral neck fracture patients with postoperative delirium died within 5 years, compared to 35 % who did not have delirium [42]. However, other authors suggest the effect of delirium on mortality rates at long follow-ups might not be independent and are actually mediated by other intervening factors. In a 2-year follow-up study, Kat et al. showed that postoperative delirium was significantly associated with long-term mortality only when interacting with severe illness at hospital admission, concluding that delirium per se is not independently associated with excess mortality [43]. In addition, Juliebo and colleagues found that postoperative delirium occurring in older hip fracture patients was associated with mortality in unadjusted analyses but was not

Table 3 Socio-demographic, pre and post-operative characteristics described according to post-operative cognitive status

	Post-operative cognitive status			
	Intact (*n* 236)	Dysfunction (*n* 145)	Delirium (*n* 133)	*p*
Socio-demographic characteristics				
Gender				.983
Women	182 (45.7 %)	113 (28.3 %)	103 (26 %)	
Men	54 (46.5 %)	32 (27.6 %)	30 (25.8 %)	
Age Class, Years				<0.001
65–79	90 (65.2 %)	34 (24.6 %)	14 (10.1 %)	
80–89	120 (43.3 %)	78 (28.1 %)	79 (28.5 %)	
≥90	26 (26.6 %)	33 (33.3 %)	40 (40.4 %)	
Age, Years (mean + SD)	80.7 + 7.4	84.1 + 6.7	86.3 + 5.8	.022
Social Situation				<0.001
Living alone	107 (61.5 %)	34 (19.5 %)	33 (18.9 %)	
Living with caregiver	129 (38.0 %)	111 (32.6 %)	100 (29.4 %)	
Education, years				<0.001
≤8	172 (40.2 %)	135 (31.6 %)	120 (28.1 %)	
>8	64 (73.5 %)	10 (11.5 %)	13 (15 %)	
Preoperative characteristics				
Barthel index, (range 0–100)				<0.001
≤80	40 (20 %)	84 (42 %)	76 (38 %)	
>80	196 (62.4 %)	61 (19.4 %)	57 (18.1 %)	
Charlson index, (range 0–21)				.246
≥4	19 (35.2 %)	18 (33.3 %)	17 (31.5 %)	
<4	217 (47.2 %)	127 (27.6 %)	116 (25.2 %)	
Polipharmacy				.621
<6	177 (45.8 %)	113 (29.2 %)	97 (25 %)	
≥6	59 (46.5 %)	32 (25.2 %)	36 (28.3 %)	
Hip Surgery Timing				.358
early (≤48 h)	134 (46.4 %)	75 (26 %)	80 (27.6 %)	
time to surgery, days	3.1 + 2.8	3.1 + 2.1	2.9 + 2.9	.567
Postoperative Characteristics				
Cumulated Ambulation Score, (range 0–18)				<0.05
>6	116 (51.3 %)	52 (23 %)	58 (25.6 %)	
<6	120 (41.6 %)	93 (32.4 %)	75 (26 %)	
Visual Analogic Scale, (range 0–10)				<0.01
>3	133 (41.2 %)	92 (28.4 %)	98 (30.3 %)	
<3	103 (53.9 %)	53 (27.7 %)	35 (18.3 %)	
GDS				<0.01
<10	149 (51.7 %)	76 (26.2 %)	63 (21.8 %)	
≥10	87 (38.5 %)	69 (30.5 %)	70 (30.9 %)	
Personal Mastery				<0.001
Negative answer	46 (30 %)	50 (32.7 %)	57 (37.3 %)	
Positive answer	190 (52.6 %)	95 (26.3 %)	76 (21 %)	

Variables are expressed as numbers and percentages. Percentages are calculated on the entire size of each row. Continuous variables were inspected using *t* test and analysis of variance when testing differences among more than two groups (ANOVA). **Key:** *Barthel Index, range 0–100*: high: >80, low: ≤80; *Charslon Index, range 0–21*: high: ≥4, low: <4; *polypharmacy:* present: >6 drugs/daily; *CAS, range 0–18*: high: ≥6; low:<6; *VAS, range 0–10*: high: >3, low:≤3. Geriatric Depression Scale, range 0–30 (<10 no depressive symptoms, >10 depressive symptoms. cognitive status: intact if MMSE > 24 and no delirium; dysfunction if MMSE ≤ 24 and no delirium; delirium if altered CAM scale at least once during 4 days after surgery, any score at MMSE

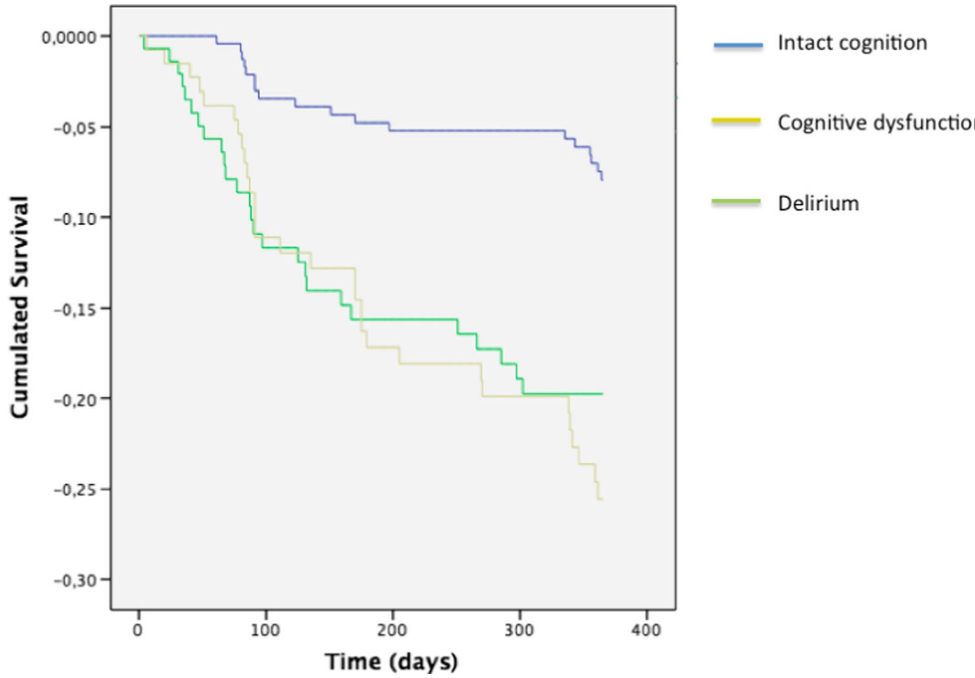

Fig. 1 Cumulated survival as calculated by Kaplan-Meier curves according to post-surgical cognitive status. Subjects scoring >24 at MMSE were labeled as having an intact cognitive function, while scores ≤24 indicated cognitive dysfunction. Independently of post-operative cognitive performance by MMSE, subjects experiencing at least one episode of delirium constituted the third group. Cumulated survival is presented as survival probability over time

significantly associated with mortality after correction for cognitive function prior to the fracture, as assessed by Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) [36]. Conversely, in our study, we found no significant difference in the mortality rates between subjects with different prefracture cognitive status, suggesting that in the investigated population, delirium does not act in synergism with dementia in predicting mortality. Furthermore, after controlling for prefracture confounding factors, including age, gender, functional status, and comorbidity burden, delirium remained significantly associated with a 2-fold risk of death within 1 year. Nevertheless, we confirm that hip fracture older men are at higher risk of death compared to women even independent of actual cognitive functions and prefracture comorbidity burden and functional status.

In recent years, an increased attention has been paid to post-operative cognitive dysfunction (POCD), partly explained, however, by the great deal of controversy and concerns raised over the topic [13]. POCD has sparsely been defined as a syndrome characterized by a drop in cognitive performance on a set of neuropsychological tests from before and after surgical care. Thus, unlike delirium, diagnosis requires administration of formal neuropsychological testing before and after surgery. Indeed, studies on POCD typically involve subjects undergoing scheduled surgical interventions [7, 11] and, moreover, do not implement a universally accepted protocol. Also, there is no International Classification of Diseases, 10th Revision code for POCD, and it is not listed as a diagnosis in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V). Therefore, cognitive assessment was carried out in all subjects using MMSE in the early post-operative phase and, in the absence of delirium, cognitive dysfunction was defined independent of the preoperative cognitive level. MMSE is an easy-to-use and universally adopted tool, suitable for cognitive evaluation in acute care settings. Detection of post-operative cognitive dysfunction was performed by using a MMSE cut-score of 24, as recommended. As with previous reports [30], the overall prevalence of post-operative cognitive dysfunction was approximately 50 %, and a significantly higher 1-year mortality rate in this group was found compared to cognitively intact individuals. Using a complete battery of neuropsychological tests covering nearly all cognitive domains, Steinmez [44] identified early (1 week after surgery) cognitive dysfunction in only 19 % of a sample of 683 elderly patients undergoing various elective major surgeries. Furthermore, in the same study, long-term mortality (median follow-up 8.5 years) was associated with cognitive dysfunction detected during a 3-month follow-up assessment, while cognitive decline at 1 week showed an increased risk of ending employment prematurely. Schaller [30] assessed elderly subjects acutely admitted to receive

Table 4 Cox regression for mortality after hip fracture

1-year mortality					
	Beta	SE	Wald	Sign	Exp
Age	.082	.020	17.442	<0.001	1.085
Gender (female)	−.688	.243	8.018	<0.01	.503
Cognitive dysfunction	.646	.307	4.442	.035	1.908
Delirium	.771	.301	6.549	0.01	2.162

surgical repair for hip fracture, using a MMSE cutoff score of 25 to identify mild to moderate cognitive impairment after surgery. Hip fracture patients with post-operative cognitive impairment were more likely to die (HR = 5.77), to be institutionalized, and re-hospitalized within 1 year of follow-up. Additional independent risk factors for mortality were male gender (HR = 3.55), low BMI (HR = 7.25), incidental infection (HR = 6.01), and baseline 25-hydroxyvitamin D level (HR = 0.93). In a similar study from Guo et al. [45], hip fracture patients with cognitive impairment had a higher mortality rate at 30 days, 6 months, and 1 year compared to unimpaired. Consistent with our findings, they found no difference in the adjusted mortality risk of cognitive dysfunction and delirium (1.9 and 2.1, respectively), supporting the hypothesis that cognitive changes occurring in the early post-operative period are crucial prognostic determinants for elderly patients with hip fracture. We can speculate that the onset of cognitive dysfunctions as well as delirium during an acute and intense stress, like hip fracture, unveils the preexisting or subclinical frailty of the individual. Clinicians and researchers should pay attention for the presence of a frailty syndrome because several pitfalls may be avoided in the clinical management and the upcoming rehabilitation program.

Recognizing changes in cognitive performances in acute care settings requires the implementation of simple, fast, and thorough bedside tests. This makes general screening tools the most suitable for this purpose. MMSE is able to assess orientation, short-term memory, language, perception and, to some degree, motor function in approximately 10 min.

The strengths of this study are the investigation of the comparison between delirium, cognitive dysfunction, and a control group using simple bedside tests, practically applicable outside the research field in routine protocol. As previously mentioned, criteria for POCD have been a matter of debate in recent years and, to date, has failed to reach standardization. Additionally, studies that used POCD definition have all been carried out on adult and young-old patients receiving scheduled cardiac and non-cardiac surgery and utilize a wide range of time-consuming neuropsychological tests [7, 11]. Moreover, the administration of assessments before and after surgical intervention might lead to a learning effect, potentially obscuring possible subtle cognitive declines [13]. We also acknowledge some major limitations of the study. This is an observational cohort study, and by design, it is not suitable for addressing causality between cognitive dysfunction and mortality. In addition, data on causes of death were not available in the study. Therefore, we were not able to detect the role of factors, such as pneumonia, falls, and orthostatic hypotension, on excess mortality in the entire sample and particularly among persons with cognitive dysfunction. This study does not contribute to the process of highlighting intermediate and modifiable factors that are more likely to be prevented compared to cancer or advanced frailty among hip fracture older persons. Additional studies are required to identify correlates of mortality and suboptimal recovery among hip fracture older persons in order to develop innovative and effective interventions beyond surgery.

Compliance with ethical standards

Conflicts of interest None.

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