Intensive Care Med (2014) 40:674–682
DOI 10.1007/s00134-014-3253-4

ORIGINAL

Prevalence and impact of frailty on mortality in elderly ICU patients: a prospective, multicenter, observational study

Pascale Le Maguet
Antoine Roquilly
Sigismond Lasocki
Karim Asehnoune
Elsa Carise
Marjorie Saint Martin
Olivier Mimoz
Grégoire Le Gac
Dominique Somme
Catherine Cattenoz
Fanny Feuillet
Yannick Malledant
Philippe Seguin

Received: 12 November 2013
Accepted: 25 February 2014
Published online: 21 March 2014

Take-home message: Frailty, a recent concept for evaluation of elderly, may help physicians in their decision-making. We showed that frailty was frequent in ICUs patients aged 65 or more, independently associated with ICU and 6 months mortalities, and better predicts outcome than usual ICU illness scores.

A related editorial is available at doi:10.1007/s00134-014-3246-3.

Electronic supplementary material
The online version of this article (doi:10.1007/s00134-014-3253-4) contains supplementary material, which is available to authorized users.

P. Le Maguet · G. Le Gac · Y. Malledant · P. Seguin
Département d'Anesthésie Réanimation, CHU Rennes, Rennes, France

A. Roquilly · K. Asehnoune
Département d'Anesthésie Réanimation, CHU Nantes, Nantes, France

S. Lasocki · M. Saint Martin
Département d'Anesthésie Réanimation, CHU Angers, Angers, France

E. Carise · O. Mimoz
Département d'Anesthésie Réanimation, CHU Poitiers, Poitiers, France

O. Mimoz
Inserm Eri 23, Poitiers, France

O. Mimoz
Université Poitiers, Poitiers, France

D. Somme · C. Cattenoz
CHU Rennes, Service de Gériatrie, Rennes, France

D. Somme · Y. Malledant · P. Seguin
Université Rennes 1, Rennes, France

F. Feuillet
EA 4275 "Biostatistique, Pharmacoépidémiologie et Mesures Subjectives En Santé", Nantes, France

Y. Malledant · P. Seguin
Inserm U991, Rennes, France

P. Seguin (✉)
Hôpital Pontchaillou, Service D'Anesthésie-Réanimation 1, Réanimation Chirurgicale, Hôpital de Pontchaillou, 2 Rue Henri Le Guilloux, 35033 Rennes Cedex 9, France
e-mail: philippe.seguin@chu-rennes.fr
Tel.: +33-2-99284246
Fax: +33-2-99282421

Abstract *Purpose:* Frailty is a recent concept used for evaluating elderly individuals. Our study determined the prevalence of frailty in intensive care unit (ICU) patients and its impact on the rate of mortality. *Methods:* A multicenter, prospective, observational study performed in four ICUs in France included 196 patients aged ≥65 years hospitalized for >24 h during a 6-month study period. Frailty was determined using the frailty phenotype (FP) and the clinical frailty score (CFS). The patients were separated as follows: FP score <3 or ≥3 and CFS <5 or ≥5. *Results:* Frailty was observed in 41 and 23 % of patients on the basis of an FP score ≥3 and a CFS ≥5, respectively. At admission to the ICU, the Simplified Acute Physiology Score II (SAPS II) and Sequential Organ Failure Assessment (SOFA) scores did not differ between the frail and nonfrail patients. In the multivariate analysis, the risk factors for ICU mortality were FP score ≥3 [hazard ratio (HR), 3.3; 95 % confidence interval (CI), 1.6–6.6; $p < 0.001$], male gender (HR, 2.4; 95 % CI, 1.1–5.3; $p = 0.026$), cardiac arrest before admission (HR, 2.8; 95 % CI, 1.1–7.4; $p = 0.036$), SAPS II score ≥46 (HR, 2.6; 95 % CI, 1.2–5.3; $p = 0.011$), and brain injury before admission (HR, 3.5; 95 % CI, 1.6–7.7; $p = 0.002$). The risk factors for 6-month mortality were a CFS ≥5 (HR, 2.4; 95 % CI, 1.49–3.87; $p < 0.001$) and a SOFA score ≥7 (HR, 2.2; 95 % CI, 1.35–3.64; $p = 0.002$). An increased CFS was associated with significant incremental hospital and 6-month mortalities.

Conclusions: Frailty is a frequent occurrence and is independently associated with increased ICU and 6-month mortalities. Notably, the CFS predicts outcomes more effectively than the commonly used ICU illness scores.

Keywords Aging · Critical care · Frail elderly · Decision-making · Mortality

Introduction

With increased life expectancy and improved medico-surgical procedures, the number of elderly patients admitted to intensive care units (ICUs) has been increasing and is expected to increase dramatically in the next decade [1–3]. However, controversies exist regarding aging as a risk factor for mortality in ICUs. Currently, identifying elderly patients who may or may not benefit from intensive treatment remains challenging, and the final decisions may be subjective [4–10]. The scoring systems currently used do not precisely assess co-morbidity and prehospital functional status or disability. Moreover, the mechanisms underlying the aging process are heterogeneous. Therefore, clinicians need a method for quantifying the interindividual variability in aging rate [11].

To achieve this objective, frailty has been recently established as a concept that is primarily investigated in the elderly population and is distinct from disability or co-morbidity [12, 13]. Frailty is characterized by a loss of physiological reserves and, consequently, an inability to maintain homeostasis to combat a disease or injury [12, 13]. The common signs and symptoms of frailty include fatigue, weight loss, weakness, low activity level, slow motor performance, and cognitive loss [12, 14]. Frailty has been associated with increased morbidity and mortality in emergency and geriatric medicine and surgery [15, 16], but it has been poorly investigated in critically ill patients [17, 18]. Therefore, understanding the relationship between frailty and ICU outcomes is becoming increasingly important.

The aim of our study was to determine the prevalence of frailty and the impact of frailty on mortality in a prospective cohort of patients aged 65 years or more who were admitted to ICUs.

Materials and methods

This prospective, observational study was conducted in four university-affiliated hospitals in France (Rennes, Nantes, Angers, and Poitiers). Recruitment was conducted from 1 November 2011 to 1 May 2012. As a non-interventional study, the local ethics committee waived the need for informed consent according to French legislation (Comité d'Ethique du CHU de Rennes, France, No. 11.39).

All of the patients aged ≥65 years and hospitalized for >24 h in the ICU were considered to be eligible for inclusion in the study. Patients were excluded if they had no proxies or could not be interviewed. For patients re-admitted to the ICU, only the first ICU hospitalization was considered. All of the patients included in the study were followed for 6 months or until death.

Data collection

Age, gender, and body mass index were recorded for each patient at the time of ICU admission. The reasons for ICU admission (medical, scheduled and unscheduled surgery, and trauma) and, more specifically, data regarding brain injury, cardiac arrest, and the presence of an infection at the time of ICU admission were collected. The severity of illness was assessed according to the Simplified Acute Physiology Score II (SAPS II) [19], the modified SAPS II (SAPS II without age) score, the Sequential Organ Failure Assessment (SOFA) score [20], and the Glasgow Coma Scale. Life expectancy was estimated using the McCabe classification [21].

During the patients' hospitalization, the following data were collected: the occurrence of severe sepsis, septic shock, acute renal failure, and acute respiratory distress syndrome; the number of acquired infections per patient; the need for dialysis; the duration of mechanical ventilation; and the need for surgery [22, 23]. The use of corticosteroids, neuromuscular blocking agents, and vasopressors was recorded. The rates of limitation and discontinued treatment were also documented.

The multidimensional syndrome of frailty in elderly, critically ill patients was assessed using two scales [12, 17]. There is no clear consensus regarding the definition of frailty, and, schematically, two operational approaches have been proposed [13]. Fried et al. validated the first operational definition, i.e., the frailty phenotype (FP), which views frailty as a biological syndrome resulting from cumulative decline across multiple physiological systems and contains five criteria (shrinking, weakness, slowness, low-level physical activity, and self-reported exhaustion) [12, 24]. All five components were considered from the previously reported definition and adapted to the ICU environment [Table 1, electronic supplementary material (ESM)] [12, 24]. The patients were considered to be frail if they had three or more frailty components among the five criteria [12]. The second

scale, the clinical frailty score (CFS), which has been adapted from the clinical frailty scale developed by Rockwood et al., views frailty as a multidimensional risk state that can be better measured by the quantity rather than by the nature of the health problems (cumulative deficit model) [17, 25]. The CFS ranges from 1 (very fit) to 9 (terminally ill), with frailty ranging from scores of 5–8 (mildly, moderately, severely, and very severely frail). The patients were considered to be frail when the CFS was ≥5 (Table 2, ESM) [17]. Moreover, the FP score and the CFS were each separated into four categories (from nonfrail to the most severely frail/terminally ill; FP score 0, 1–2, 3, and >3 and CFS 1–3, 4, 5, and >5), and the hospital and 6-month mortalities were studied for each category.

Furthermore, disability was quantified using the Katz Index of Independence in Activities of Daily Living (ADL), which assesses the ability of patients to perform the daily activities of bathing, dressing, toileting, transferring, continence, and feeding. This index correlates with physical dependence. Patient dependence was described in one of two manners for each function: independent (1 point) or dependent (0 point). The ADL score ranges from 0 (complete dependence) to 6 (complete independence) [26]. The burden of co-morbidity was quantified using the Charlson Co-morbidity Index, which is based on the assignment of co-morbidities observed in patients in one of several categories [27]. A weighted score is assigned to each co-morbidity on the basis of the relative risk of 1-year mortality. The sum of the index scores is an indicator of disease burden and a predictor of death [27]. Memory status was assessed by asking relatives if they had noticed whether the patient had exhibited memory problems in the last 6 months. It was quantified as present if the patient had trouble remembering the names of people he/she had recently met, had trouble remembering the flow of a conversation, and had an increased tendency to misplace items.

The FP, CFS, Katz Index of Independence in ADL, and presence or absence of a memory disorder were obtained as soon as possible from the patient, when possible, or his/her relatives. The Charlson Co-morbidity Index was obtained from the patient, when possible, or his/her relatives [spouse, children, and sibling(s)]; the referring physician; and the patient's medical charts. Moreover, on the basis of the possible interference between these scores and the acute illness requiring ICU admission, the patient or his/her relatives were asked to extrapolate the patient's status 1-month before hospital admission.

The ICU and hospital lengths of stay and the ICU, hospital, and 6-month mortalities were recorded. Finally, for all of the patients who survived the ICU, their final location (home, hospital, or other institution) after 6 months was recorded.

Statistical analysis

All of the statistical analyses were performed using SAS 9.1 Statistical Software (SAS Institute, Cary, NC, USA). The quantitative variables are expressed as the mean ± standard deviation, and the qualitative variables are expressed as numbers (percentages). The patients were divided into two independent groups, namely, frail and nonfrail patients, on the basis of an FP score <3 or ≥3 and a CFS <5 or ≥5, respectively. For descriptive statistics, the categorical variables were compared using the χ^2 test or Fisher's exact test, as required. The continuous variables were compared using Student's t test. The survival variables were compared using the log rank test, and Kaplan–Meier survival curves were constructed.

To build the model for multivariate analysis, we selected among the variables with a $p \leq 0.20$ according to the univariate analysis. Subsequently, survival regression (Cox proportional hazard model) was performed to identify the independent factors associated with ICU and 6-month mortalities. The hazard ratios (HRs) and 95 % confidence intervals (95 % CIs) were calculated. The model fit and calibration were assessed using the c-index. A $p < 0.05$ was considered to be statistically significant for all of the comparisons.

Results

During the 6-month study period, 961 patients were admitted to the ICUs. A total of 309 elderly patients ≥65 years old, hospitalized >24 h, and consecutively admitted to the ICUs were assessed for eligibility, and 196 were analyzed (Rennes, $n = 107$; Nantes, $n = 49$; Angers, $n = 22$; and Poitiers, $n = 18$) (Fig. 1, ESM). Details regarding the ICUs and institutions from which the patients were recruited are presented in Table 3 of the ESM. The frailty data were collected at the time of admission by querying the patients (31 %), their relatives (61 %), or both (8 %).

Frailty was observed in 80 patients (41 %) and 46 patients (23 %) of the 196 patients on the basis of an FP score ≥3 and a CFS ≥5, respectively (Table 1). The CFS was significantly correlated with the FP score ($R^2 = 0.66$, $p < 0.001$). At baseline, frail patients had significantly higher numbers of severe underlying diseases, co-morbidities, disabilities, and memory disorders (Table 1). During ICU hospitalization, the limitation or discontinuation of treatment was significantly more frequent in patients who had a CFS ≥5 (Table 2). There were no differences in ICU and hospital lengths of stay between the frail and nonfrail patients, regardless of the measurement modalities used to assess frailty (Table 2).

Table 1 Baseline characteristics, frailty, disability and co-morbidity scores, and memory status

	Total ($n = 196$)	Not frail FP <3 ($n = 116$)	Frail FP ≥3 ($n = 80$)	p	Not frail CFS <5 ($n = 150$)	Frail CFS ≥5 ($n = 46$)	p
Age, years	75 ± 6	74 ± 6	75 ± 6	0.96	75 ± 6	76 ± 7	0.34
Sex, male	128 (65)	72 (62)	56 (70)	0.25	100 (67)	28 (61)	0.47
BMI, kg m^{-2}	28 ± 6	28 ± 5	28 ± 8	0.45	28 ± 5	30 ± 10	0.12
Type of admission							
Medical	50 (26)	31 (27)	19 (24)		34 (23)	16 (35)	
Scheduled surgery	52 (26)	24 (21)	28 (35)	0.09	42 (28)	10 (22)	0.25
Unscheduled surgery	76 (39)	47 (40)	29 (36)		58 (39)	18 (39)	
Trauma	18 (9)	14 (12)	4 (5)		16 (11)	2 (4)	
At admission							
Brain injury	40 (20)	28 (24)	12 (15)	0.12	32 (21)	8 (17)	0.56
Cardiac arrest	15 (8)	8 (7)	7 (9)	0.60	8 (5)	7 (15)	0.05
Infection	85 (43)	46 (40)	39 (49)	0.21	64 (43)	21 (46)	0.72
SAPS II	48 ± 17	49 ± 17	47 ± 16	0.52	48 ± 17	49 ± 16	0.51
Modified SAPS II[a]	33 ± 16	32 ± 16	33 ± 17	0.52	32 ± 17	34 ± 16	0.57
SOFA	7 ± 4	7 ± 4	7 ± 3	0.65	7 ± 4	7 ± 3	0.93
Glasgow coma scale	11 ± 5	11 ± 5	11 ± 5	0.51	11 ± 5	11 ± 5	0.98
McCabe score							
A	88 (45)	64 (55)	24 (30)		75 (50)	13 (28)	
B	85 (43)	43 (37)	42 (52)	0.0014	61 (41)	24 (52)	0.02
C	23 (12)	9 (8)	14 (18)		14 (9)	9 (20)	
CFS	3.7 ± 1.6	2.9 ± 1.3	4.8 ± 1.3	<0.0001	–	–	–
FP	–	–	–	–	1.7 ± 1.4	3.3 ± 1.1	<0.0001
Charlson score	2.1 ± 2.0	1.8 ± 1.8	2.5 ± 2.1	0.006	1.9 ± 2.0	2.6 ± 1.9	0.05
Katz score	5.3 ± 1.5	5.8 ± 0.8	4.6 ± 2.0	<0.0001	5.8 ± 0.9	3.7 ± 2.1	<0.0001
Memory disorders	43 (22)	18 (16)	25 (31)	0.01	27 (18)	16 (35)	0.02

Quantitative and qualitative values are expressed as the mean ± SD and n (%)

[a] The modified SAPS II score was SAPS II not including age

BMI body mass index, *SAPS II* simplified acute physiologic score II, *SOFA* sequential organ failure assessment, *FP* frailty phenotype, *CFS* clinical frailty score

Table 2 Clinical data during ICU hospitalization and ICU and hospital length of stay

	Total ($n = 196$)	Not frail FP <3 ($n = 116$)	Frail FP ≥3 ($n = 80$)	p	Not frail CFS <5 ($n = 150$)	Frail CFS ≥5 ($n = 46$)	p
Severe sepsis	73 (37)	44 (38)	29 (36)	0.81	58 (39)	15 (33)	0.46
Septic shock	68 (35)	39 (34)	29 (36)	0.70	54 (36)	14 (30)	0.49
Number of acquired infections	0.8 ± 0.8	0.9 ± 0.9	0.8 ± 0.7	0.31	0.9 ± 0.9	0.7 ± 0.6	0.13
Acute renal failure	83 (42)	43 (37)	40 (50)	0.07	64 (43)	19 (41)	0.87
Dialysis	41 (21)	25 (22)	16 (20)	0.79	33 (22)	8 (17)	0.50
Mechanical ventilation, days	11 ± 15	12 ± 15	10 ± 15	0.35	10 ± 14	12 ± 20	0.54
ARDS	14 (7)	8 (7)	6 (8)	0.87	12 (8)	2 (4)	0.53
Surgery	98 (50)	61 (53)	37 (46)	0.38	74 (49)	24 (52)	0.74
Corticosteroid treatment	43 (22)	22 (19)	21 (26)	0.23	31 (21)	12 (26)	0.44
Use of neuromuscular blocking	24 (12)	14 (12)	10 (13)	0.93	20 (13)	4 (9)	0.40
Vasopressor use	113 (58)	68 (59)	45 (56)	0.74	91 (61)	22 (48)	0.12
Limitation or discontinuance of treatment	38 (19)	18 (16)	20 (25)	0.10	18 (12)	20 (43)	<0.0001
Length of stay, days							
ICU	8 (5–17)	10 (5–18)	7 (4–14)	0.21	9 (5–18)	8 (4–14)	0.96
Hospital	23 (13–47)	24 (13–50)	21 (13–42)	0.15	24 (13–49)	22 (13–42)	0.26

Quantitative and qualitative values are expressed as the mean ± SD or median (interquartile range) and n (%)

ARDS acute respiratory distress syndrome, *FP* frailty phenotype, *CFS* clinical frailty score

Figure 1 depicts survival probability according to the FP score and CFS status. Only ICU mortality was higher among frail-FP patients, whereas frail-CFS patients had significantly higher ICU, hospital, and 6-month mortality rates (Fig. 2). According to the CFS, nonfrail patients were more likely to live at home (Fig. 2).

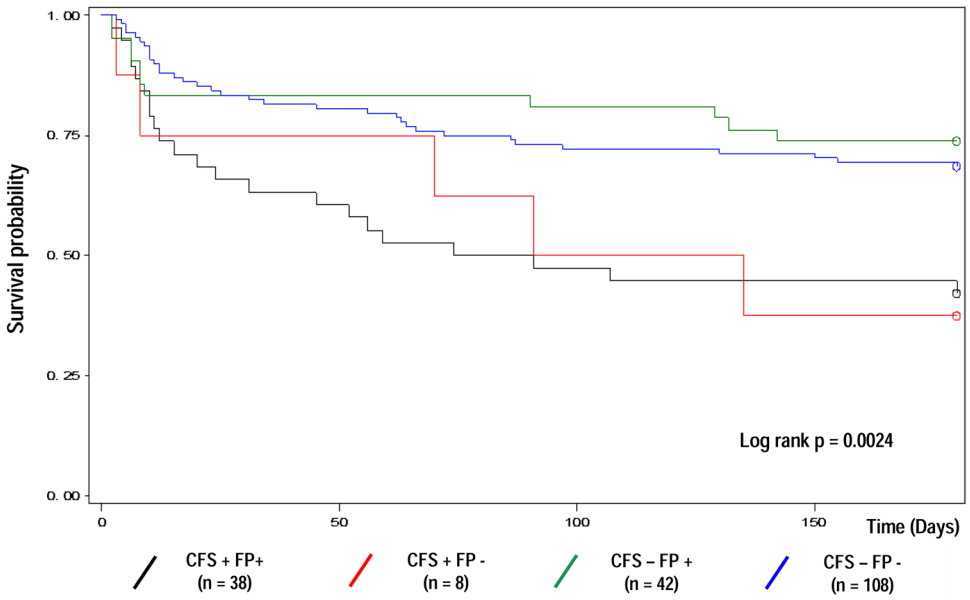

Fig. 1 Kaplan–Meier survival curves for 6-month mortality according to the frailty phenotype and clinical frailty score status

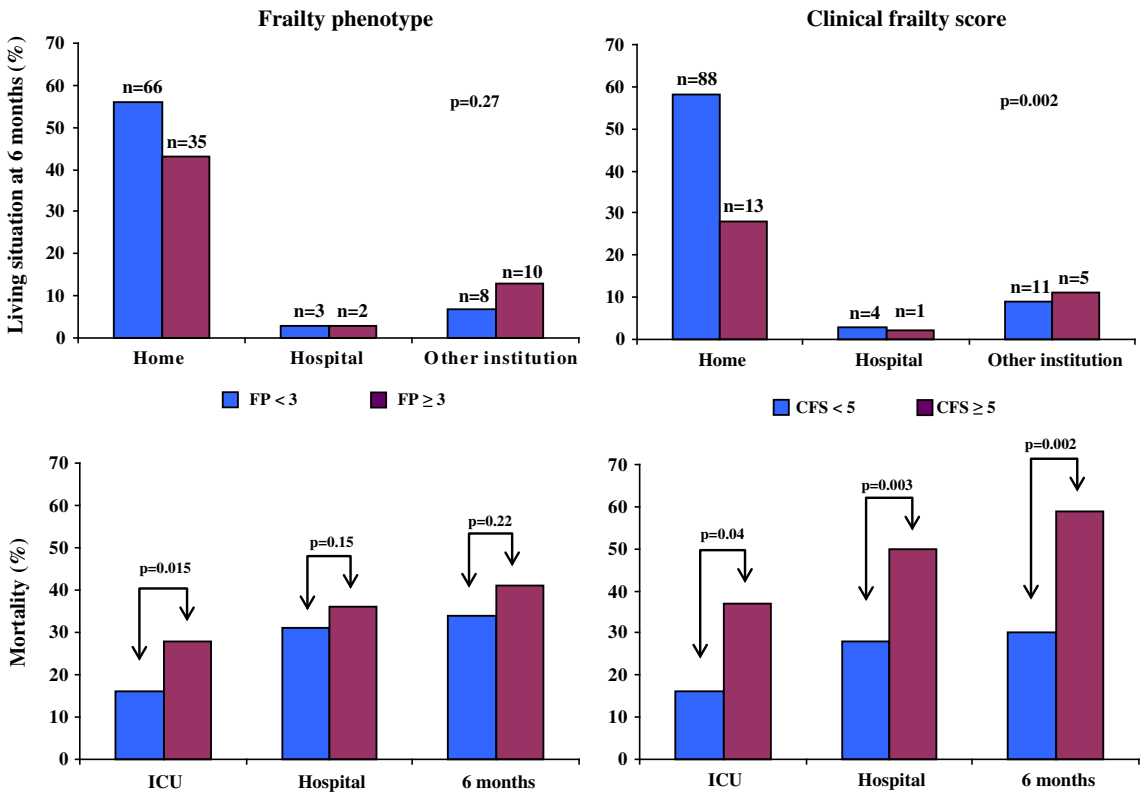

Fig. 2 Living situation at 6 months and ICU, hospital, and 6-month mortalities versus frailty status

Table 3 provides hospital and 6-month mortality rates according to the increasing levels of the FP scores and CFSs. An increase in the CFS was associated with significant incremental hospital and 6-month mortalities.

The univariate analysis of ICU and 6-month mortalities is provided in Tables 4 and 5 in the ESM. In the multivariate analysis, the risk factors for ICU mortality were an FP score ≥3 (HR, 3.3; 95 % CI, 1.6–6.6;

Table 3 ICU, hospital, and 6-month mortalities according to the level of frailty

	ICU mortality ($n = 41$)	$p^{\dagger}$	Hospital mortality ($n = 65$)	$p^{\dagger}$	6-Month mortality ($n = 72$)	$p^{\dagger}$
Frailty phenotype						
0 ($n = 36$)	10 (28)	0.02	11 (31)	0.11	11 (31)	0.09
1–2 ($n = 80$)	9 (11)		25 (31)		28 (35)	
3 ($n = 36$)	7 (19)		9 (25)		10 (28)	
4–5 ($n = 44$)	15 (34)		20 (45)		23 (52)	
Clinical frailty score						
1–3 ($n = 88$)	16 (18)	0.21	26 (30)	0.003	28 (32)	<0.001
4 ($n = 62$)	8 (13)		16 (26)		17 (27)	
5 ($n = 19$)	7 (37)		7 (37)		7 (37)	
6–8* ($n = 27$)	10 (37)		16 (59)		20 (74)	

* For CFS = 9, $n = 0$

† Log rank test

$p < 0.001$), male gender (HR, 2.4; 95 % CI, 1.1–5.3; $p = 0.026$), cardiac arrest before admission (HR, 2.8; 95 % CI, 1.1–7.4; $p = 0.036$), a SAPS II ≥46 (HR, 2.6; 95 % CI, 1.2–5.3; $p = 0.011$), and brain injury before admission (HR, 3.5; 95 % CI, 1.6–7.7; $p = 0.002$) [c-index = 0.76 (0.45; 0.99)]. The risk factors for 6-month mortality were a CFS ≥5 (HR, 2.4; 95 % CI, 1.5–3.9; $p < 0.001$) and a SOFA ≥7 (HR, 2.2; 95 % CI, 1.3–3.6; $p = 0.002$) [c-index = 0.75 (0.53; 0.93)].

Discussion

In this prospective study involving ICU patients ≥65 years old, 41 and 23 % were considered to be frail at the time of admission according to the FP score and CFS, respectively. Frailty constitutes an independent risk factor for ICU and 6-month mortalities. These results are consistent with a recent study performed in a younger population of ICU patients aged ≥50 years, which showed that frailty evaluated by the CFS was associated with an increased risk of adverse events, morbidity, and mortality [18].

In our study, age did not appear to be a predictive factor of death; however, this result is a controversial issue. Recently, a large retrospective study in patients ≥75 years of age reported a linear increase in the adjusted mortality probability at 28 days from ICU admission and at 1 year among the 28-day ICU survivors [9]. Similarly, aging was independently associated with a higher mortality rate in patients suffering from circulatory failure [28]. Nevertheless, evidence suggests that factors other than age itself, notably, previous health status, play a pivotal role in outcome [4, 10]. In a medical ICU, in patients ≥80 years old, long-term mortality was shown to be independently associated with the presence of an underlying fatal disease and severe functional limitations [4]. Similarly, although focused on the long-term quality of life after ICU admission, a reduction in health-related quality of life was observed up to 36 months after ICU admission and was related to the effects of pre-existing diseases [10].

To better define long-term outcomes in elderly individuals, it is important to include other parameters, such as disability and co-morbidity, rather than chronologic age and the common illness severity scores [29]. Frailty is a state of increased vulnerability in elderly adults, which is distinct from disability and co-morbidity; however, an overlap exists between these entities [14]. The prevalence of frailty is approximately 7 % in the general population ≥65 years old [12, 14], although a higher prevalence (>40 %) has been reported, particularly in patients who are hospitalized for various reasons [14, 25, 30, 31]; these prevalence differences could be a result of the different frailty models used [32]. Geriatric frail patients are predisposed to hospitalization, institutionalization, and decreased survival [14, 25, 31]. Frailty was identified to be a major predictor of postoperative complications and death after scheduled or unscheduled surgery [16, 30].

It is not surprising that several components of a pre-existing frailty syndrome may compromise rehabilitation and outcome. An ICU hospitalization is an exhausting experience; after discharge from the ICU, the majority of patients have early substantial functional disabilities in ADL [33]. We studied long-term mortality but did not evaluate health-related quality of life (HRQOL), which has been controversially reported to be impaired in the elderly after ICU discharge [34, 35]. Nevertheless, frail ICU patients reportedly had a lower HRQOL at 6 and 12 months, regardless of their physical and mental status, which reinforces the importance of the "frail" versus "nonfrail" status at the time of admission [18]. Moreover, in the ICU, severe weakness is recognized to be a complication that, in turn, significantly impacts the recovery and return to former functional status of patients who survive organ failures [36]. Although valid for all patients, these points are more important for elderly

individuals. The early recognition of frailty may help to identify targets for interventions to reduce the functional decline related to critical illness and ICU stay [36, 37].

Our results are consistent with those in previous reports, performed in areas other than ICUs [25, 38]. Frailty, independent of age, is a risk factor for ICU and 6-month mortalities. Notably, the FP score is associated with ICU mortality, whereas the CFS is associated with 6-month mortality. The assessment of functional measures provided by the FP score may be subjective, particularly when ascertained from surrogate decision-makers or family, and may explain the differences between the two scores. However, two operational definitions of frailty, namely, the FP score and CFS, were proposed because they responded to two different approaches regarding the concept of frailty, and they capture related but distinct groups of patients. In a recent study performed in a geriatric population, the prevalence of frailty ranged from 6 to 45 % when eight commonly used scales were compared [32]. The FP score is known to more precisely evaluate sarcopenia and decreased functional reserves with the loss of resilience to stressors and is likely to be more relevant for the ICU environment. The CFS, which explores the physical aspects and the environmental spectrum, appears to be more relevant for delayed mortality [13].

Upon first admission to the ICU, frail patients were more dependent and had more memory problems and co-morbidities than nonfrail patients; however, the common markers of illness severity at the time of admission and during hospitalization were not different between frail and nonfrail patients. The severity of illness scoring systems used in the ICU (i.e., APACHE II, SAPS II, and SOFA) are largely dominated by the assessment of acute physiological derangements that are present at the time of admission, although several researchers incorporate a limited assessment of confirmed advanced co-morbid illnesses [17, 39]. This point underscores the importance of determining the frailty status in ICU patients to assess the need for increasing the duration of hospitalization and institutionalization and to predict mortality.

Our study has several limitations. For example, the threshold of 65 years of age used for patient inclusion in this study may be criticized. Nevertheless, it is generally accepted that elderly individuals are at least 65 years old. The threshold of $\geq$65 years old has been frequently used to characterize frailty in ICU patients, although frailty may also exist in younger individuals [12, 18, 24, 25]. Several components of the FP score, notably those that evaluate performance, were difficult to explore in ICU patients, which could explain the differences between the FP scores and CFS [12, 24]. In accordance with a geriatrician's advice, we chose to interpret slowness as difficulty walking while aided and the occurrence of a fall. Other components of frailty were easier to translate because clear substitutes were available [24]. The majority of the questionnaires, notably those for the FP score, were completed by the next-of-kin and may be over- or underscored as a consequence. However, in the ICU, this approach is routine and can be considered to be the "real life" and pragmatic approach, although the next-of-kin tend to underestimate the patient's abilities and the degree of family ties may modify the relevance of the responses [40, 41]. Finally, during ICU hospitalization, the limitation or discontinuation of treatment was more frequent in frail patients and may have contributed to the increased mortality rates in these patients. This potential bias is difficult to avoid because the weight of the frailty status in the decisions to withhold/withdraw therapy has not been studied; other factors are usually considered in these types of decisions. Similarly, 20 % of our patients suffered a brain injury and 8 % suffered cardiac arrest; thus, it could be argued that in these patients, the decision of whether to withdraw support may be different for frail and nonfrail patients. Nevertheless, we did not find any difference in the support withdrawal practice between these patient subgroups (Tables 6 and 7, ESM) or between the four ICUs studied (Tables 8 and 9, ESM).

Conclusions

As the number of elderly patient admissions to the ICU continues to increase, physicians must identify the predictive factors of mortality. At the time of admission, the common markers of illness severity (SAPS II and SOFA), as assessed by ICU physicians, did not differ between the frail and nonfrail patients. The frailty status is frequently assessed and allows for a better definition of the risk of death in elderly patients, particularly using the CFS, although the use of the frailty score in decision-making regarding the withdrawal of support must be approached with caution.

Acknowledgments We thank Aurore Hoarau and Veronique Sebille (EA 4275 Biostatistique, Recherche Clinique et Mesures Subjectives en Santé, Université of Nantes Faculté de Médecine, Nantes Cedex 1, France) for their help in performing the statistical analysis and Kenneth Rockwood for providing constructive comments.

Conflicts of interest PLM, AR, EC, MSM, OM, GLG, DS, CC, FF, YM, and PS declare that they have no conflicts of interest. SL has received consulting fees from Viforpharma. KA has received lecturing and consulting fees from Braun, Astellas, and Fresenius.

References

1. Kvåle R, Flaatten H (2002) Changes in intensive care from 1987 to 1997—has outcome improved? A single centre study. Intensive Care Med 28:1110–1116. doi:10.1007/s00134-002-1378-3
2. Blot S, Cankurtaran M, Petrovic M, Vandijck D, Lizy C, Decruyenaere J, Danneels C, Vandewoude K, Piette A, Vershraegen G, Van Den Noortgate N, Peleman R, Vogelaers D (2009) Epidemiology and outcome of nosocomial bloodstream infection in elderly critically ill patients: a comparison between middle-aged, old, and very old patients. Crit Care Med 37:1634–1641. doi:10.1097/CCM.0b013e31819da98e
3. Ihra GC, Lehberger J, Bauer P, Schmutz R, Metnitz B, Metnitz PGH (2012) Development of demographics and outcome of very old critically ill patients admitted to intensive care units. Intensive Care Med 38:620–626. doi:10.1007/s00134-012-2474-7
4. Boumendil A, Maury E, Reinhard I, Luquel L, Offenstadt G, Guidet B (2004) Prognosis of patients aged 80 years and over admitted in medical intensive care unit. Intensive Care Med 30:647–654. doi:10.1007/s00134-003-2150-z
5. de Rooij SE, Govers A, Korevaar JC, Abu-Hanna A, Levi M, de Jonge E (2006) Short-term and long-term mortality in very elderly patients admitted to an intensive care unit. Intensive Care Med 32:1039–1044. doi:10.1007/s00134-006-0171-0
6. Sacanella E, Pérez-Castejon JM, Nicolas JM, Masanés F, Navarro M, Castro P, López-Soto A (2009) Mortality in healthy elderly patients after ICU admission. Intensive Care Med 35:550–555. doi:10.1007/s00134-008-1345-8
7. Boumendil A, Angus DC, Guitonneau AL, Menn AM, Ginsburg C, Takun K, Davido A, Masmoudi R, Doumenc B, Pateron D, Garrouste-Orgeas M, Somme D, Simon T, Aegerter P, Guidet B; ICE-CUB study group (2012) Variability of intensive care admission decisions for the very elderly. PLoS One 7:e34387. doi:10.1371/journal.pone.0034387
8. Sprung CL, Danis M, Iapichino G, Artigas A, Kesecioglu J, Moreno R, Lippert A, Curtis JR, Meale P, Cohen SL, Levy MM, Truog RD (2013) Triage of intensive care patients: identifying agreement and controversy. Intensive Care Med 39:1916–1924. doi:10.1007/s00134-013-3033-6
9. Fuchs L, Chronaki CE, Park S, Novack V, Baumfeld Y, Scott D, McLennan S, Talmor D, Celi L (2012) ICU admission characteristics and mortality rates among elderly and very elderly patients. Intensive Care Med 38:1654–1661. doi:10.1007/s00134-012-2629-6
10. Orwelius L, Nordlund A, Nordlund P, Simonsson E, Bäckman C, Samuelsson A, Sjöberg F (2010) Pre-existing disease: the most important factor for health related quality of life long-term after critical illness: a prospective, longitudinal, multicentre trial. Crit Care 14:R67. doi:10.1186/cc8967
11. Rusinova K, Guidet B (2014) Are you sure it's about 'age'? Intensive Care Med 40:114–116. doi:10.1007/s00134-013-3147-x
12. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA; Cardiovascular Health Study Collaborative Research Group (2001) Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 56:146–156. doi:10.1093/gerona/56.3.M146
13. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K (2013) Frailty in elderly people. Lancet 381:752–762. doi:10.1016/S0140-6736(12)62167-9
14. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G (2004) Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci Med Sci 59:255–263. doi:10.1093/gerona/59.3.M255
15. Dasgupta M, Rolfson DB, Stolee P, Borrie MJ, Speechley M (2009) Frailty is associated with postoperative complications in older adults with medical problems. Arch Gerontol Geriatr 48:78–83. doi:10.1016/j.archger.2007.10.007
16. Lee DH, Buth KJ, Martin BJ, Yip AM, Hirsch GM (2010) Frail patients are at increased risk for mortality and prolonged institutional care after cardiac surgery. Circulation 121:973–978. doi:10.1161/CIRCULATIONAHA.108.841437
17. McDermid RC, Stelfox HT, Bagshaw SM (2011) Frailty in the critically ill: a novel concept. Crit Care 15:301. doi:10.1186/cc9297
18. Bagshaw SM, Stelfox HT, McDermid RC, Rolfson DB, Tsuyuki RT, Baig N, Artiuch B, Ibrahim Q, Stollery DE, Rokosh E, Majumdar SR (2013) Association between frailty and short- and long-term outcomes among critically ill patients: a multicentre prospective cohort study. CMAJ 25:E95–E102. doi:10.1503/cmaj.130639
19. Le Gall JR, Lemeshow S, Saulnier F (1993) A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. JAMA 270:2957–2963. doi:10.1001/jama.1993.03510240069035
20. Vincent JL, Moreno R, Takala J, Willatts S, De Mendonça A, Bruining H, Reinhart CK, Suter PM, Thijs LG (1996) The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med 22:707–710. doi:10.1007/BF01709751
21. McCabe WR, Jackson GG (1962) Gram-negative bacteremia. Arch Intern Med 110:847–855. doi:10.1001/archinte.1962.03620240029006
22. Bone RC, Balk RA, Cerra FB, Dellinger RP, Fein AM, Knaus WA, Schein RM, Sibbald WJ; ACCP/SCCM Consensus Conference Committee (1992) Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis: The ACCP/SCCM Consensus Conference Committee, American College of Chest Physicians/Society of Critical Care Medicine. Chest 101:1644–1655. doi:10.1378/chest.101.6.1644
23. Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P (2004) Acute renal failure: definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. Crit Care 8:R204–R212. doi:10.1186/cc2872

24. Avila-Funes JA, Helmer C, Amieva H, Barberger-Gateau P, Le Goff M, Ritchie K, Portet F, Carrière I, Tavernier B, Gutiérrez-Robledo LM, Dartigues JF (2008) Frailty among community-dwelling elderly people in France: the three-city study. J Gerontol A Biol Sci Med Sci 63:1089–1096. doi:10.1093/gerona/63.10.1089
25. Rockwood K, Howlett SE, MacKnight C, Beattie BL, Bergman H, Hébert R, Hogan DB, Wolfson C, McDowell I (2004) Prevalence, attributes, and outcomes of fitness and frailty in community-dwelling older adults: report from the Canadian study of health and aging. J Gerontol A Biol Sci Med Sci 59:1310–1317. doi:10.1093/gerona/59.12.1310
26. Katz S, Downs TD, Cash HR, Grotz RC (1970) Progress in development of the index of ADL. Gerontologist 10:20–30
27. Charlson ME, Pompei P, Ales KL, MacKenzie CR (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 40:373–383
28. Biston P, Aldecoa C, Devrient J, Beattie BL, Bergman H, Hébert R, Hogan DB, Wolfson C, McDowell I (2014) Outcome of elderly patients with circulatory failure. Intensive Care Med 40:50–56. doi:10.1007/s00134-013-3121-7
29. Minne L, Ludhikhuize J, de Jonge E, de Rooij S, Abu-Hanna A (2011) Prognostic models for predicting mortality in elderly patients: a systematic review. Intensive Care Med 37:1258–1268. doi:10.1007/s00134-011-2265-6
30. Robinson TN, Wu DS, Stiegmann GV, Moss M (2011) Frailty predicts increased hospital and six-month healthcare cost following colorectal surgery in older adults. Am J Surg 202:511–514. doi:10.1016/j.amjsurg.2011.06.017
31. Cawthon PM, Marshall LM, Michael Y, Dam TT, Ensrud KE, Barrett-Connor E, Orwoll ES; Osteoporotic Fractures in Men Research Group (2007) Frailty in older men: prevalence, progression, and relationship with mortality. J Am Geriatr Soc 55:1216–1223. doi:10.1111/j.1532-5415.2007.01259.x
32. Theou O, Brothers TD, Mitnitski A, Rockwood K (2013) Operationalization of frailty using eight commonly used scales and comparison of their ability to predict all-cause mortality. J Am Geriatr Soc 61:1537–1551. doi:10.1111/jgs.12420
33. van der Schaaf M, Dettling DS, Beelen A, Lucas C, Dongelmans DA, Nollet F (2008) Poor functional status immediately after discharge from an intensive care unit. Disabil Rehabil 30:1812–1818. doi:10.1080/09638280701673559
34. Roch A, Wiramus S, Pauly V, Forel JM, Guervilly C, Gainnier M, Papazian L (2011) Long-term outcome in medical patients aged 80 or over following admission to an intensive care unit. Crit Care15:R36. doi:10.1186/cc9984
35. Hofhuis JG, van Stel HF, Schrijvers AJ, Rommes JH, Spronk PE (2011) Changes of health-related quality of life in critically ill octogenarians: a follow-up study. Chest 140:1473–1483. doi:10.1378/chest.10-0803
36. Griffiths RD, Hall JB (2010) Intensive care unit-acquired weakness. Crit Care Med 38:779–787. doi:10.1097/CCM.0b013e3181cc4b53
37. Wood KA, Ely EW (2003) What does it mean to be critically ill and elderly? Curr Opin Crit Care 9:316–320. doi:10.1097/00075198-200308000-00011
38. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL, Hillier TA, Cauley JA, Hochberg MC, Rodondi N, Tracy JK, Cummings SR (2008) Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Arch Intern Med 168:382–389. doi:10.1001/archinternmed.2007.113
39. Knaus WA, Draper EA, Wagner DP, Zimmerman JE (1985) APACHE II: a severity of disease classification system. Crit Care Med 13:818–829. doi:10.1097/00003246-198510000-00009
40. Capuzzo M, Grasselli C, Carrer S, Gritti G, Alvisi R (2000) Quality of life before intensive care admission: agreement between patient and relative assessment. Intensive Care Med 26:1288–1295. doi:10.1007/s001340051341
41. Hofhuis J, Hautvast JL, Schrijvers AJ, Bakker J (2003) Quality of life on admission to the intensive care: can we query the relatives? Intensive Care Med 29:974–979. doi:10.1007/s00134-003-1763-6